Operator's Manual
HYPER RAPID 50
Industrial Picosecond Laser System

COHERENT®
Opelstraße 10
67661 Kaiserslautern, Germany

GERMANY

Coherent Kaiserslautern GmbH
Opelstr. 10
D–67661 Kaiserslautern
Germany

Tel.: +49 (6301) 32013-180
Fax: +49 (6301) 32013-189

email: tech.sales@coherent.com
Service: Service.KL@coherent.com

U.S.A

Coherent Inc.
5100 Patrick Henry Drive
Santa Clara, CA 95054 USA

Tel.: +1 (408) 764-4000
Fax: +1 (408) 764-4800

email: tech.sales@coherent.com

JAPAN

Coherent Japan Office
Tokyo MK Building
7-2-14 Toyo, Koto-Ku, Tokyo
135-0016, Japan

Tel.: +81 (3) 5635-8700
Fax: +81 (3) 5635-8701

Internet: www.coherent.co.jp

KOREA

Coherent Asia Korea
Eagle Town 1F, 5F, 278-20,1
Seongsu 2ga-3 dong Seongdong-Gu,
Seoul, 133-832, Korea

Tel.: +82 (2) 450-7900
Fax: +82 (2) 460-7901

www.coherent.com

Edition April 2015 *hyper_50_AOM*

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This Operator's Manual replaces all previous versions.

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1 Preface

Read this Operator's Manual carefully before operating the laser for the first time. Special attention must be given to information in section "Safety" on page 13.

1.1 Signal Words and Symbols in this manual

This documentation contains sections in which particular hazards are defined or special attention is drawn to particular conditions. These sections are indicated with signal words in accordance with ANSI Z–535.6 and safety symbols (pictorial hazard alerts) in accordance with ANSI Z– 535.3 and ISO 7010.

1.1.1 Signal Words

Four signal words are used in this documentation: **DANGER**, **WARNING**, **CAUTION** and ***NOTICE***. All of them include the additional possibility of device failure or damage if ignored.

The signal words **DANGER**, **WARNING** and **CAUTION** designate the degree or level of hazard when there is the risk of injury:

DANGER!
Indicates a hazardous situation that, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.

WARNING!
Indicates a hazardous situation that, if not avoided, could result in death or serious injury.

CAUTION!
Indicates a hazardous situation that, if not avoided, could result in minor or moderate injury.

NOTICE!
Indicates information considered important, but not hazard-related.

1.1.2 Symbols

The signal words **DANGER**, **WARNING** and **CAUTION** are always emphasized with a safety symbol that indicates a special hazard, regardless of the hazard level:

This symbol is intended to alert the operator to a general hazard and the presence of important instructions.

This symbol is intended to alert the operator to danger of exposure to hazardous visible and/or invisible laser radiation.

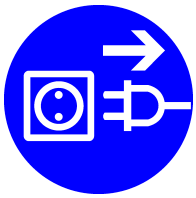
This symbol is intended to alert the operator to the presence of dangerous voltages within the product enclosure that may be of sufficient magnitude to constitute a risk of electrical shock.

This symbol is intended to alert the operator to the danger of lifting hazard and/or heavy weight.

This symbol indicates corrosive, irritant components.

This symbol indicates a magnetic and/or electro-magnetic field.

Eye protection and adequate protective clothing, which are appropriate for the existing (potentially various) laser radiation, have to be worn.



Switch off and unplug from mains before working with or opening the device.

Refers to important information and notes.

Refers to an external document for further information.

2 Safety

This safety section must be thoroughly reviewed, understood and executed prior to operating the HYPER RAPID 50 laser system. Safety instructions presented throughout this manual (as well as related manuals) must be followed carefully.

This Operator's Manual must be available at any time to any person working with or in vicinity to the laser system. It has to be read, understood and applied by any person in charge of carrying out work with and on the system devices.

Persons working nearby (direct and maybe also indirect vicinity) have to be informed about all possible hazards related to the system.

CAUTION!
Use of controls or adjustments or performance of procedures other than those specified in this manual may result in hazardous radiation exposure.

2.1 General Safety

Not observing all instructions of this manual may result in injury, damage the laser and/or void of warranty. Breakage of any seal without prior written authorization of the manufacturer will void all liabilities of the manufacturer and warranty claims of the user.

The laser radiation interacting with any material may generate dust, gases or aerosols that can be potentially harmful to human health, environment polluting, inflammable and / or even explosive. Ensure that appropriate exhaust devices are in place and make sure that they are operational and in use. The exhausted air and filters have to be cleaned and treated in accordance with environmental regulations. Waist products have to be properly disposed.

Safety devices (e.g. emergency stop button, interlocks, etc.) are never allowed to be modified, shortcut or overridden.

Avoid interaction of the beam with explosives, flammable or combustible materials.

It is not allowed to remove any mechanical parts. Do not loosen elements which belong to the laser head or power supply. Do not destroy, damage or remove any seal or label.

An operator / user is defined as a person trained and certified for operating the laser in order to get the desired result. He is not allowed to use any tool on the laser system (nor supply units). Maintenance is limited to trained and certified personnel, service is limited to Coherent service engineers.

2.2 Laser Classification

The HYPER RAPID 50 is a class 4 laser in accordance with EN 60825–1 (IEC 60825–1). All local safety regulations must be satisfied (e.g. in Germany: Regulations for the avoidance of accidents BGV B2).

The HYPER RAPID 50 laser meets the US Federal Regulations of 21 CFR subchapter J part 1040.10. Regarding this standard the system emits Class IV level of laser radiation.

The HYPER RAPID 50 laser meets the 47 CFR part 15 to control radio noise generated by industrial, scientific and medical (ISM) equipment.

The HYPER RAPID 50 laser meets the requirements laid down in Council Directive 2006/95/EC relating to "Low Voltage Directive" and 2004/108/EC relating to "Electromagnetic Compatibility".

2.3 General hazards

Hazards associated with lasers generally fall into the following categories:

- Exposure to laser radiation that may damage the eyes or skin
- Electrical hazards generated in the laser power supply or associated circuits
- Electro-magnetic devices inside the laser head
- Chemical hazards resulting from contact of the laser beam with volatile or flammable substances, or released as a result of laser material processing.

The above list is not intended to be exhaustive. Anyone operating the laser must consider the interaction of the laser system with its specific working environment to identify potential hazards.

2.4 Optical Safety

Laser light, because of its special qualities, poses safety hazards not associated with light from conventional sources. The safe use of lasers requires all operators, and everyone near the laser system, to be aware of the dangers involved. Users must be familiar with the instrument and the properties of coherent, intense beams of light.

The safety precautions listed below are to be read and observed by anyone working with or near the laser. At all times, ensure that all personnel who operate, maintain or service the laser are protected from accidental or unnecessary exposure to laser radiation exceeding the accessible emission limits listed in the European Community standards EN 60825-1, clause 9 and in the "Performance Standards for Laser Products", United States Code of Federal Regulations, 21 CFR 1040 10 (d).

WARNING!
Direct eye contact with the output beam from the laser will cause serious damage and possible blindness.

The greatest concern when using a laser is eye safety. In addition to the main beam, there are often secondary beams present at various angles near the laser system. These beams are formed by specular reflections of the main beam at polished surfaces such as lenses, beam splitters, jewelry, watches, etc.. While weaker than the main beam, such beams may still carry sufficient intensity to cause eye damage.

Laser beams are powerful enough to burn skin, clothing or paint even at some distance. They can ignite volatile substances such as alcohol, gasoline and other solvents, and can damage light-sensitive elements in (video-) cameras, photo-multipliers and photo diodes. The user is advised to follow the precautions below.

2.4.1 Recommended Precautions

- All personnel have to wear laser safety glasses rated to protect against the specific wavelengths in accordance with EN 207.

- Never look directly into the laser beam or reflected by surfaces; also not with protective eye wear.
- Avoid wearing watches, jewelry, or other objects that may reflect or scatter the laser beam.
- Stay away of the laser beam path, particularly when external optics are used to steer the beam.
- Provide enclosures for beam paths whenever necessary and possible.
- Use appropriate energy-absorbing targets for beam blocking.
- Block the beam before applying tools such as Allen wrenches or ball drivers to external optics.
- Limit access to the laser to qualified users who are familiar with laser safety practices. When not in use, the system is supposed to be shut down completely and made unaccessable to unauthorized personnel. Remove the key-switch (located at the laser power supply's front side).
- Use the laser in an enclosed room. Laser light may remain collimated over long distances and therefore presents a potential hazard if not confined. It is good practice to operate the laser in a room with controlled access.
- Warning signs and signal lamps indicating the presence of laser beam. Position these signals to adequate locations.
- Exercise extreme caution when using solvents/gases in the area of the laser.
- Never look directly into the laser light source (also not when turned off). Never sight down the beam.
- Set up the laser so that the beam height is either well below or well above eye level.

2.5 Electrical Safety

Inside the laser system high voltages (greater than mains) are generated which could cause electric shock or injury if not operated according to the procedures described in this Operator's Manual. Also electro-magnetic fields are present.

DANGER!
Never open devices or remove covers. Removing the cover of the laser head or any power supply will expose the user to potentially lethal electrical hazards. Work with open devices is limited to Coherent Service employees only.

WARNING!
Any break in the electrical ground conductors, whether inside or outside the laser units, or disconnection of the electrical ground connection could create a hazardous condition. Ensure that all ground connections are effectively connected to "earth".

WARNING!
The HYPER RAPID 50 laser generates high electro-magnetic fields. Users with pacemakers and/or surgical implants shall not work beside or with the laser system without first consulting their physician. Credit cards or any media with magnetic data could be damaged. This kind of storage has to be kept away from the system.

2.5.1 Recommended Precautions

The following precautions must be observed by everyone when working with potentially hazardous electrical circuitry:

- Disconnect main power lines before working on any electrical equipment when it is not necessary for the equipment to be operating.
- Protection against possible hazards requires proper connection of the ground (earth) terminal on the power cable, and an adequate external ground. Check these connections at the time of installation, and periodically thereafter.

2.6 Integrated Lasers

The HYPER RAPID 50 system incorporates fiber lasers. Beams and illuminations from these laser sources are hazardous. They might be invisible. Wavelength and power are indicated on the corresponding label.

Laser fibers lead the light from the power supply to the laser head. These fibers need to be handled very carefully. Never bend, break, crack or cut a laser fiber. Any mechanical forces are to be avoided. The fibers might need to be covered, tubed or adequately guided.

2.7 Safety devices

In order to prevent the emission of laser radiation, there are three possible mechanisms:

- shutter during normal operation
- emergency stop button located at the power supply
- external interlock.

2.7.1 Shutter

The ***shutter*** is a laser-internal safety unit. If it is closed, no laser radiation can be emitted out of the laser system.

There are three possibilities to control the shutter:

- via software, see section "Main window" on page 59
- via DLL, see external Software description
- via the external shutter connector (6-pin female connector), see section "IL/Shutter connector" on page 53. This hardware based interlock overrules the software controlled one.

Via the external 8-pin female connector the status of the shutter can be read out, see section "Status connector" on page 55.

2.7.2 Emergency Stop

The ***Emergency stop*** button is located at the power supply's front side (section "Power supply" on page 50). When activated (pressed), the laser power supply is switched off. The chiller remains active. The reason of activation (or any possible error) has to be solved before the emergency stop button is allowed to be released. In order to release the emergency button, it must be rotated and pulled out. The power supply restarts. The laser diodes have to be activated separately (via Software). The operation of the laser system is exclusively possible with released (pulled out) emergency button.

2.7.3 Interlock circuit

The hardware based ***interlock*** circuit is a safety mechanism of the laser system. When the interlock gets activated, the laser diodes are turned off (powered-down) and the shutter is being closed. The laser power supply as well as the chiller remain active. The status can be seen in the software and with the ***Status connector*** (section "Status connector" on page 55). The interlock circuit consists of the following components:

Cooling	The system continuously controls the water flow, pressure, temperature, and water level of the chiller. The interlock is being activated if one of these parameters fall out of the required range.
Temperature of laser diodes	Also the temperature of the assigned pumping diodes (seed laser and amplifiers) are tracked.
Key switch	The key switch on the front side of the power supply has to be in position I in order to enabling the switch-on. In position 0 the interlock is open and the power supply cannot be switched on. In this position the key can be removed to prevent unintended (or unauthorized) power-on.
IL/Shutter (external interlock)	Hardware controlled, external shutter interlock (section "IL/Shutter connector" on page 53). For the required integration of this safety feature consult your laser safety officer.

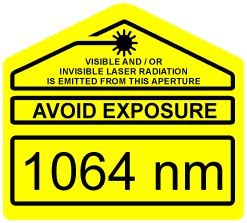
2.8 Safety Labels – Warning

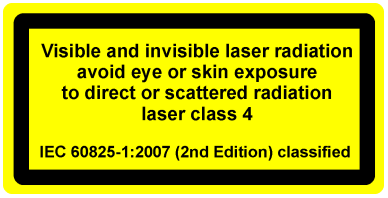
The following warning is valid for all labels attached to laser system including supply units and chiller.

CAUTION!
Never remove safety labels. Lost labels have to be replaced. The customer is responsible, that persons working with or nearby the laser have read and understand the meaning of all labels. This information needs to be available to any (involved) person any time.

2.9 Safety Labels – laser head

In the following list all safety labels located on the laser head are described.

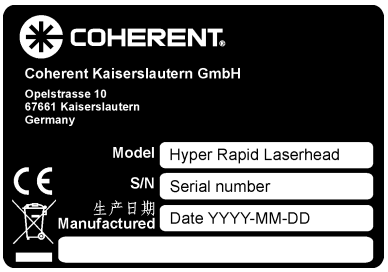
1	
	Laser radiation output in indicated direction with the corresponding wavelength (1064 nm depending on order).

2	
	DANGER: laser radiation, avoid direct or indirect exposure

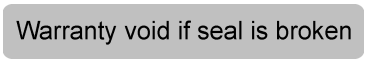
3	
	DANGER: laser radiation, direct and indirect when cover open

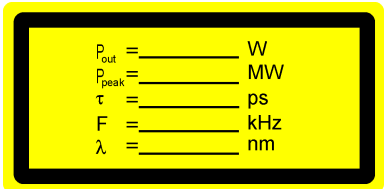
4	
	DANGER: laser radiation Class 4 / Class IV laser

5	
	CAUTION: laser radiation

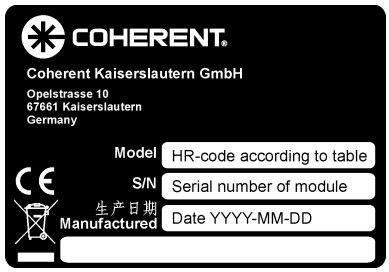
6	
	Identification label of the laser head

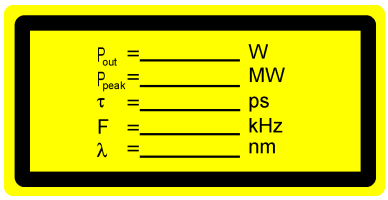
7	
	Identification label of the laser system

8	
	Seal (do not break, cut or remove)

9	
	Laser Parameters

10	
	(not present)

11	
	Identification label of the module Example: HR-AOM-1064 Product name: HR=Hyper Rapid AOM indicates the process shutter

12	
	Output specifications

2.9.1 Location on the laser head

All labels listed in the table above can be found on the laser head shown in the following illustration:

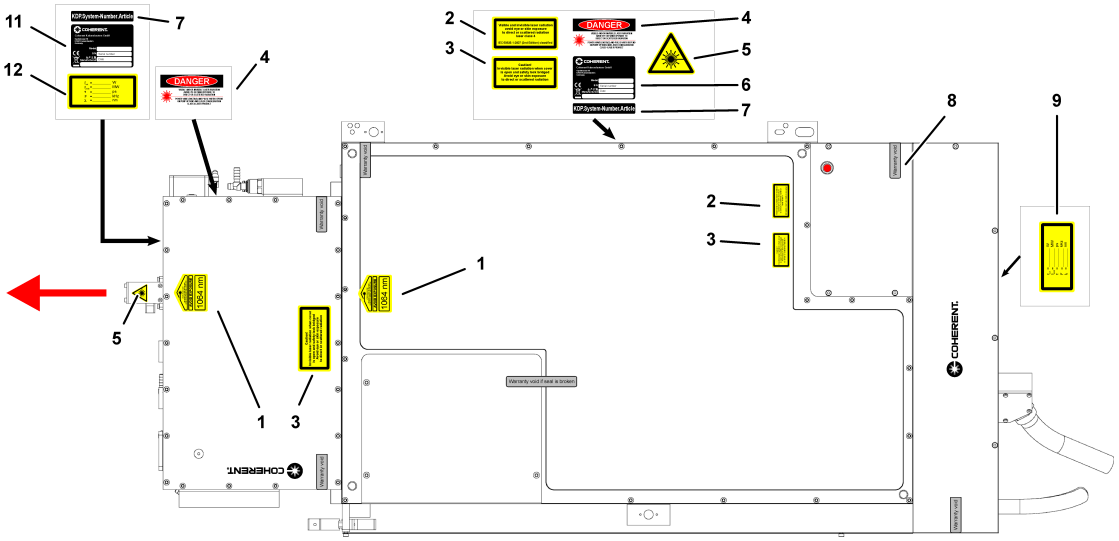


Figure 1: location of safety labels on the laser head

2.10 Safety Labels – power supply

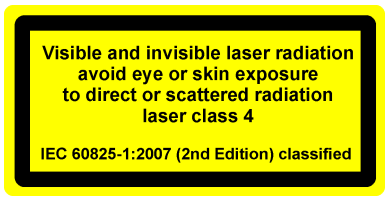
In the following list all safety labels located on the power supply are described.

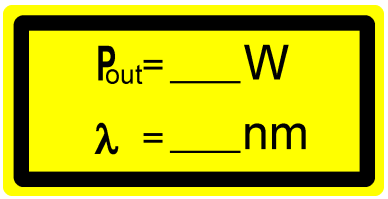
1	
	Emergency Button

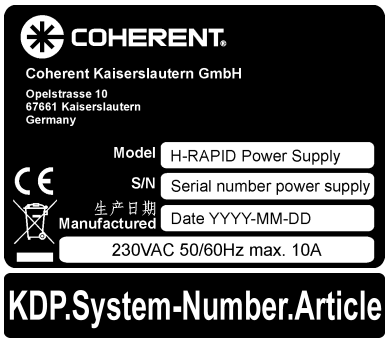
2	
	Caution: laser radiation

3	
	DANGER: laser radiation Class 4 / Class IV laser

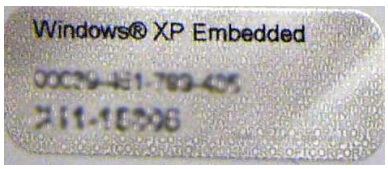
4	
	Coherent Logo

5	
	Caution: laser radiation, avoid direct or indirect exposure

6	
	Indicates optical output power and wavelength of connected laser-diodes /-fibers

7	
	Identification label – power supply Identification label – system

8	
	High Voltage present, disconnect before opening

9	
	Microsoft Windows license

10	

2.10.1 Location on the power supply

All labels listed in the table above can be found on the power supply shown in the following illustration:

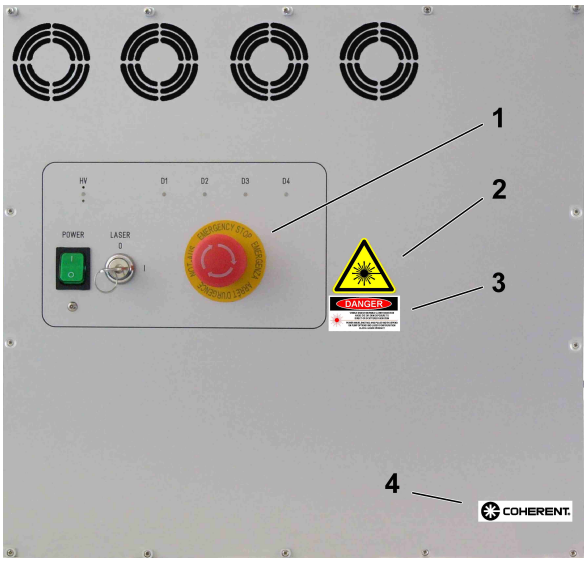


Figure 2: Front view of the power supply

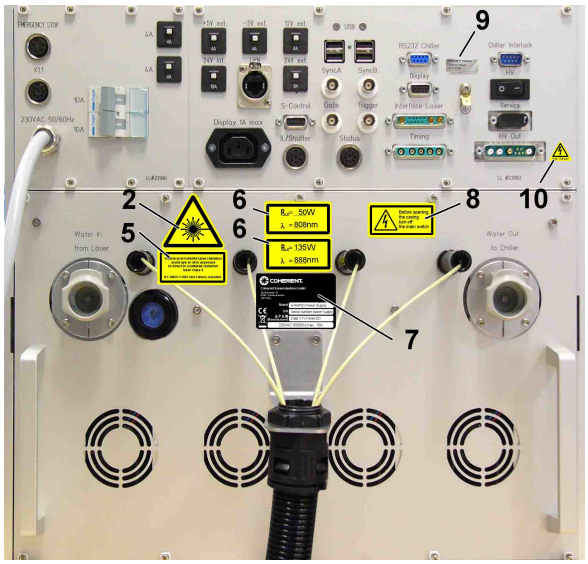


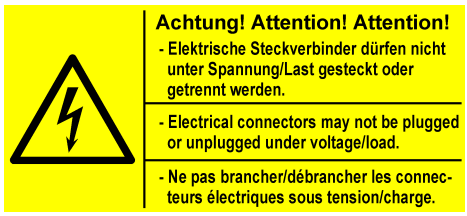
Figure 3: Rear view of the power supply

2.11 Safety Labels – Chiller

In the following list all safety labels located on the chiller are described. Some labels are located on top of the housing and are not visible when integrated into the control-unit rack.

1	TERMOTEK AG LASERKÜHLUNG CE RoHS 03/2006 76532 Baden-Baden; Im Rollfeld 6 Tel: 07221/9711-0 www.termotek-ag.com Typ: PXXX-xxxxx cooling capactiy: xxxx W at xx°C water / xx°C environment pump performance: xx l/min at x bar power supply: xxx V, xx Hz, xx A refrigeration gas: R134a serial-no: xxxxx year: MM/YYYY
	Identification label (located on the rear side of the chiller) Type: P320-16434 water-air Type: P320-17256 water-water

2	WARNING WARNUNG AVERTISSEMENT Equipment contains pressurised liquid, rotating parts hot pipes and high voltage. Do not use with panels removed. Isolate before opening. Do not adjust safety cutout devices or temperature control parameters without consultation. Das Gerät enthält eine unter Druck stehende Flüssigkeit, rotierende Teile und hohe Spannung. Das Gerät darf nicht mit abgenommenen Paneelen betrieben werden. Das Gerät vor dem Öffnen von der Stromversorgung trennen. Verändern Sie keine Sicherheitsbauteile und/oder die Parameter der Temperatursteuerung ohne vorherige Konsultationen. L'équipement contient: liquide sous pression, pièces rotatives, tuyaux chauds & haute tension. Ne pas utiliser avec les panneaux enlevés. Isoler avant d'ouvrir. Ne pas ajuster les dispositifs de mise hors circuit de securité ni les paramétres de réglage des températures sans consultation préalable.
	Equipment contains pressurized liquid, rotating parts hot pipes and high voltage. Do not use with panels removed. Isolate before opening. Do not adjust safety cutout devices or temperature control parameters without consultation.

3	
	Attention! Electrical connectors may not be plugged or unplugged under voltage/load.

3 Introduction

The HYPER RAPID 50 laser is a highly innovative ultrashort pulse laser of the newest generation.

In this laser system all advantages of an ultrashort-pulse laser and an industrial laser with excellent beam quality, high power, high repetition rates and high reliability together with low operation costs are combined.

The Picosecond laser HYPER RAPID 50 is special equipment which must only be used by qualified and trained personnel following the instructions of this manual.

The HYPER RAPID 50 laser emits laser radiation that can permanently damage eyes and skin.

3.1 Typographic conventions

The following typographic conventions are used in this Operator's Manual:

bold italic	Indicates system features, functions or interfaces
Main Menu	Description of a software-function / -dialog
`monospace`	Software commands, file names or directories
<abc>	Indicates variables which must be replaced with real values

3.2 Intended Use

The system is meant for industrial micromachining. The Picosecond pulses lead to a so-called *cold ablation*. This guides to a new quality of the machined area, because any disturbing thermal side effects like microcracks, burr or recast are completely excluded. This laser is suitable for high quality micromachining of nearly any material with spatial resolution in the µm / nm range. This rugged laser is built for 24/7-operation in an industrial environment. Working with the laser is without creating any mechanical forces or tool abrasion.

Sample applications are drilling, cutting, marking, scratching, hardening, polishing, micro-welding and surface structuring of various materials.

The system is designed for material processing, as well as measuring/scanning, in atmospheric environment, in-door-use, horizontal alignment, relatively motionless during emission and free of vibration. It is not qualified for under-water use, zero gravity or telecommunication. Furthermore demonstrative applications (e.g. laser-shows) are not allowed. Combustible or explosive materials are prohibited to be processed by the laser. Note that equally chemical or physical reactions could result in such products.

All safety directives and instructions have to be followed. Manipulation or opening the system is prohibited. The manufacturer does not take responsibility for damages or injuries due to inappropriate operation as well as not-intended use.

DANGER!
Use of the system in a manner other than described herein may result in injury, damage and/or void of warranty.

3.3 Warranty

The warranty conditions are specified in the sales contract.

Do not open the laser head housing. An electrical interlock switch installed in the HYPER RAPID 50 laser head stops laser operation, when the cover of the protective housing is opened.

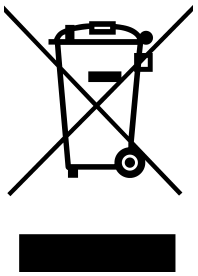
Any unauthorized modification (opening included) of the laser, power supply, chiller, software or any other additional component will result in invalidity of the guarantee and service contract.

3.4 Declaration of conformity

CE

This laser system is in compliance with all European regulations, as applicable. Therefore the laser is labeled with the CE mark. A declaration of conformity is available upon request from Coherent Kaiserslautern GmbH.

3.5 Disposal of the laser



The European Waste Electrical and Electronic Equipment (WEEE) Directive is represented by a crossed-out garbage container label. The purpose of this directive is to minimize the disposal of WEEE as unsorted municipal waste and to facilitate its separate collection.

4 Installation

The HYPER RAPID 50 laser may only be installed by a qualified service engineer of Coherent observing all safety aspects.

NOTICE!

Refer to the external instruction "Unpacking instruction" located on the delivery box as well as on the Documentation-CD.

Located on the delivery boxes are (each) 4 labels indicating the safe shipment of the laser. 2 SHOCK-WATCHES are positioned diagonal and 2 TILTWATCH-labels are located in an 90° angle to each other. Inside the laser head box is one additional TILTWATCH indicator. The condition of all indicators shall be checked directly after arrival.

Check the packages as well as the content for any damages. Document each defect (written and via photos) and let the transportation company sign. Inform Coherent Kaiserslautern GmbH.

WARNING!

The installation is exclusively allowed for qualified Coherent personnel. Instructions of this manual as well as all safety issues have to be observed and followed. To ensure that the system operates correctly, the installation site for the laser shall meet the requirements described in the manual.

NOTICE!

We recommend to store the original packaging material and instructions in order to send the laser to another destination or back to Coherent for Service. Refer to the external document "Packing instructions" for important information concerning the preparation of shipment.

4.1 Installation requirements

The HYPER RAPID 50 laser is intended for indoor use only. The laser shall be operated under clean room conditions. Ensure the safety of the laser at any time. In case of doubt ask your laser safety officer (LSO).

WARNING!
The door to the area, in which the laser is operated, must have danger signs and warning lamps. The door may require an interlock circuit.

CAUTION!
The laser head, as well as other components of the system, is relatively heavy. Adequate lifting devices should be used in order to prevent accidents or system damages. Use the 4 attachable handles (included in delivery). The weight of the laser head is approx. 115 kg (253 lbs).

NOTICE!
Refer to the external instruction "Pre-Installation Guide" for important installation information. It is located on the Documentation-CD.

Closing the Gate does not completely prevent residual radiation. An amount of radiation is still emitted and might need to be guided into an appropriate beam dump.

- Place the laser head on a level surface in the upright position. For secure transportation use the laser head handles. Any relevant safety issues needs to be followed like wearing safety shoes.
- Do not place the laser head next to instruments that cause vibration, electromagnetic interference, or have high inductance.
- Electrical conducted interference, created by other devices, are not allowed and need to be avoided.
- Do not place the laser head in direct sunlight or close to radiators or heating devices.
- Adequate customer table with thread holes in order to position and mount the laser head. Refer to section "Footprint, Pedestals" on page 35.

- Provide electrical connectors for the power supplies. Provided by the manufacturer are CEE 7/4 "Schuko" (alternatively C20 if ordered) connectors or blank cable ends. If the voltage deviates from 230 VAC, a transformer will be delivered. In this case one connector (valid for approx. 30 A) is necessary.
- All plugs used with the HYPER RAPID 50 laser system shall have the same phasing to prevent electronic noise generated by other instruments or by the power supply itself.
- Removing or attaching devices or any other changes as well as opening the system is not allowed. Modification would require the specific approval of Coherent Kaiserslautern GmbH.
- Use only the cables supplied with the system, refer to section "Scope of delivery".
- Internal connectors (optical-, electrical- or water-) are not allowed to be replaced, dismounted or exchanged.
- The laser fibers between laser head and power supply rack are adjusted and cannot be disconnected.
- Do not place any devices on top of the laser head.
- In case the system is being implemented into an enclosed laser-processing-area, adequate door lock devices as well as shutter control via safety element might be required.
- In case the system is being implemented into an enclosed laser-processing-area, it might be necessary to take cable- and hose-lengths into account, especially if power supplies are required to being separated from each other (refer to section "Schematical Design" on page 42).
- Guarantee proper ventilation of the laser system by keeping the ventilation slots clear. Extracted air should be leaded out (fresh air should be supplied in).
- All devices have to be connected to ground. Prerequisite for a functional ground conduction is that the house internal ground circuit is also connected to ground.
- The laser system must be supplied with a voltage of 230 V. In case the house supply deviates from this voltage, a transformer (belongs to delivery) is obligatory to be used. Check if the transformer voltage complies the mains voltage before connecting. All laser system components have to be connected to the transformer.

- Observe the flow direction when connecting the chiller hoses: The coolant of the internal circuit flows from the chiller into the laser head, into the power supply and back into the chiller (closed water loop system). All hoses are prepared with the CPC fasteners and just need to be plugged into the adequate plugs.
- Laser fibers have to be handled carefully. Do not pitch, squeezed, crack or break the fibers. Mechanical, thermal, chemical or any other forces are not allowed. Fibers need to be installed securely without the risk of any mechanical contact. Use a guidance rail or tube with a minimum bending radius of 10 cm (4 inches).
- The IL/Shutter connector (located at the power supply's rear side) is required to be replaced by a real safety circuit. In order to enable the system, the interlock chain must be closed (see section "IL/Shutter connector" on page 53).
- Remove the transportation cover in front of the output beam exit port.

WARNING!
Check the chiller input-voltage. The voltage must match with the house-internal mains voltage. In case of deviation, the voltage must be adjusted (transformer). Check device instructions. Do not switch on the chiller (or laser system) before making sure that both voltages match.

4.2 Space and power requirements

The HYPER RAPID 50 laser head needs to be placed to an appropriate position.

Dimensions	The dimensions of the system can be found in section "Specifications" on page 37. For detailed information concerning the fitting dimensions, construction drawings can be requested (position of beam output, etc.). The values indicated in this manual can deviate from real dimensions (e.g. for non-standard configuration).
Power	The required voltage is 230 VAC / 50 Hz. From this specification deviating values are made possible by using a transformer (needs to be ordered). In this case all components need to be connected via transformer.
Ventilation	Guarantee proper ventilation of the device by keeping the ventilation slots clear. Make sure that ventilation inlets of the control unit rack are not obstructed.
Access	A minimum clearance of about 40 cm (15 inches) must be available between the back of the laser head as well as the control unit rack (or integrated power supply & chiller) and the wall, to allow access to the connectors. Ensure sufficient accessibility for the Service to the laser head (top- and sideways). In case the space is critical we recommend to contact Coherent Kaiserslautern GmbH.

4.3 Transportation and operation conditions

During storage, transport, within an OEM-system, for the installation and during operation, the ambient conditions must be observed. Ensure reasonable transport conditions, free of major shocks, jolt or fall. Protect the whole system against frost, gases, moisture and dust. Use original packing material for relocation.

Before unpacking the laser wait for 6 hours to allow for thermalization of all components.

Temperature range during transportation	+5°C to +50°C (41°F up to 122°F)
Relative humidity during transportation	10% up to 90%, non-condensing
Temperature range for optimal operation	+15°C up to +27°C (59°F up to 80°F)
Relative humidity during operation	<60%, non-condensing
Maximum altitude for operation	2000 meters above sea level (850 – 1050 hPa)

Transportation at lower temperatures shall be avoided. The whole cooling system needs to be completely drained and blown dry.

CAUTION!
Environmental conditions that exceed these specifications could result in instrument failure. Keep the HYPER RAPID 50 laser in a dry place. Moisture could cause malfunction. Mistreatment may damage the device, in particular the output window.

NOTICE!
In case customer components are being added to the system, consider that the environmental conditions could deviate (permitted range of ambient temperature, humidity, etc.).

4.4 Scope of delivery

The following table lists the delivered components. In order to check the completeness of all components use the checklist coming with the delivery or the contract.

Amount	Part
1	HYPER RAPID 50 laser head
1	Power supply
1	Chiller
1	Monitor, Keyboard, Mouse
1	Line cord G1544 (for the monitor)
1	Presentation folder (includes Final Report & Documentation-CD)
2	Laser key A126
1	DIN Interlock plug SV-60 shorted (just for testing)
1	DIN Interlock plug SV-60 for integration of an interlock-circuit
1	DIN Status plug for integration
1	DIN Emergency stop plug for integration
1	Allen key set, metric (Industrial mounting kit, hex. screw)
1	Breadboard mounting kit (pedestal screws)
4	Handles L652/95 M12x30
1	Line cord for power supply
1	Line cord for chiller
1	CKL-1 chiller liquid (ready to use)

Amount	Part
1	Water change kit (short hoses with CPC-connectors)
2	Serial cable for chiller
1	Laser service kit (filter, desiccant cartridges)
2	Pair of gloves
1	Diodes kit in transparent box (shortcut bridge, protective caps)
1	Transportation cover in front of (each) output-window
1	Optional: transformer (only when mains voltage deviate from 230 V)

4.5 Footprint, Pedestals

We recommend to position the laser head on a horizontal, flat ground surface made of a low expansion material (ideally granite) in order to eliminate temperature and vibration issues. (A modern alternative might be cast stone).

Dimensions and locations of the 3 pedestals can be found in the CAD file (request from Coherent Kaiserslautern GmbH if required). These feet have to be fixed with 3 screw-packages and 2 alignment pins (included in delivery). The alignment pins (DIN 7979, ISO 8735, Form D, fit: m6, measure: 6x24 mm) are necessary to ensure an exact position of the laser head. One is designed as a fixed bearing (foot 1) and one as long hole (foot 2) (refer to drawings below for details).

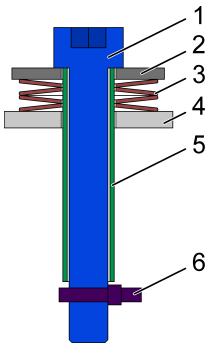
The three M6–screws require a thread-hole in the ground-table of at least 12 mm thread-depths. Note that the mechanical connection (as included in delivery) (screw, sleeve, washers and spring-package) is designed to minimize or exclude (thermal caused) mechanical stress. Therefore observing this procedure is important and necessary. This mounting method is exclusively valid for laser-operation.

In order to transporting the laser head inside a machine, additional transport-clamps are required. These clamps have to be removed after arrival / for operation. Include additional threads into your table for this purpose.

The upper side of the feet are made of aluminum, the bottom side consist of PVC in order to achieve a thermal isolation.

Fasten the screws (M6x40) with a torque of **3.5 Nm**. This is – on purpose– a relatively low torque to avoid mechanical tension inside the laser head. The holding force is generated by the disc-springs. Additionally, temperature differences as well as vibrations have to be reduced / avoided. If one (or more) of these parameters exceeds, the consequence could be loss of optical power or even failure of the system.

CAUTION!
The fastening torque of the pedestal-screws (M6x40) is 3.5 Nm. Do not use any other screw or stronger torque. For transportation additional fixing / clamping devices are temporarily required. Temperature differences and vibrations are to be avoided.



1 cylinder head screw, M6x40

2 washer (steel)

3 disk spring package

4 plastic washer (PA)

5 spacer sleeve (aluminum)

6 cable strap (remove before using the screw package)

5 Specifications

5.1 Laser head

The HYPER RAPID 50 laser is a diode-pumped mode-locked laser system with ultra-short pulses and high pulse energy.

Instrument type	Class 4 / Class IV OEM laser
Dimensions (W x D x H)	581 x 1296 x 195 mm (22.9 x 51 x 7.7 inches)
Weight	approx. 115 kg (253 lbs)

5.2 Power Supply

The power supply matches the size of a 9 U, 19" slot and can be integrated into customer systems.

Dimensions (W x D x H)	485 x 555 x 400 mm (19 x 21.9 x 15.8 inches)
Weight	55 kg (121 lbs)
Power supply	230 VAC / 50-60 Hz max. 10 A, tolerance: ±10%, differing voltage (100,110,208 V) with optional transformer
Power consumption	approx. 1300 W
Noise level	<70 dB(A) (measured with power supplies & chiller)
Protection class	I (protective grounding)

5.3 Chiller

The chiller matches the size of a 9 U, 19" slot and can be integrated into customer systems.

Dimensions (W x D x H)	485 x 600 x 400 mm (19 x 23.6 x 15.8 inches)
Weight	65 kg (143 lbs)
Power supply	230 VAC / 50-60 Hz (differing voltage with optional transformer)
Power consumption	approx. 1800 W
Ventilation (in case of water-air chiller)	Ensure a proper heat exchange by guaranteeing a free ventilation of fresh and "cold" air. In order to transport enough energy a straight and not obstructed air-flow must be maintained.
Primary water supply (in case of water-water chiller)	The flow rate of the external water circuit shall provide at least: 10 l/min (2.65 US gallons/minute) at 5 bar (max.). The water temperature has to be between 5°C and 25°C (41°F and 77°F). 2 not-transparent water hoses (in&out), inner-diameter: 1/2 inch (CPC connectors for attaching the chiller will be provided on delivery).

6 System description

The HYPER RAPID 50 is an ultra-short-pulse laser with Pico-second-pulses. It emits short pulses with a pulse length of 7-10 ps in the infrared wavelength range (1064 nm).

The HYPER RAPID 50 laser is intended for industrial applications as well as an OEM laser source.

6.1 Pulse picking

The seeder laser within the HYPER RAPID 50 laser head generates a constant pulse train with a repetition rate of 50 MHz. An EOM (electro-optical modulator) – called pulse picker – selects single pulses out of the pulse train to reduce the effective pulse rate. The selected pulses are going to be amplified in order to gain the required energy. The unused pulses are deflected into a beam dump.

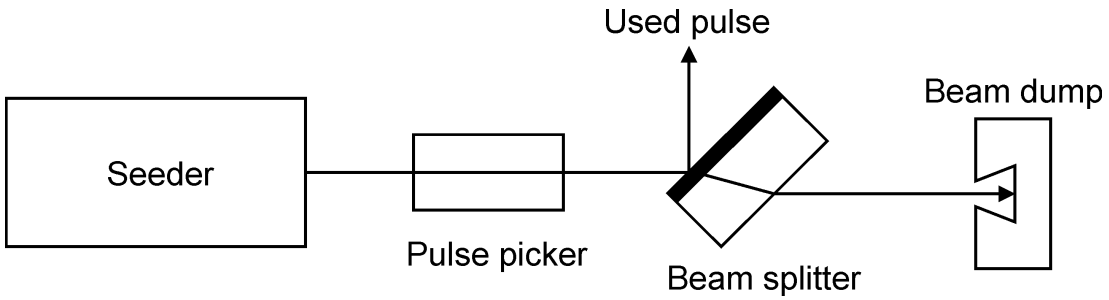
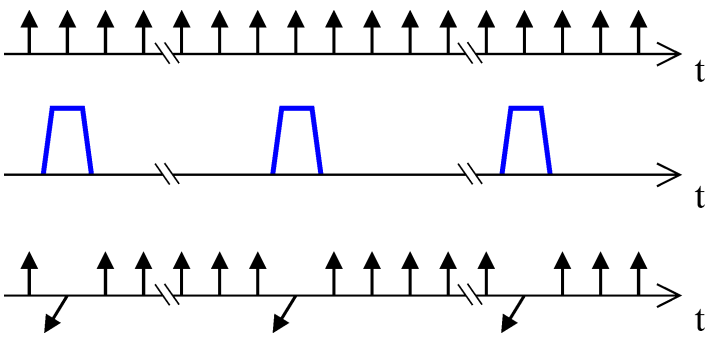


Figure 4: Principle function of pulse picker

An EOM works like an optical separator. By applying a fast high voltage signal the electrical field changes the polarization of single pulses. A subsequent polarization filter leads the pulse to deviated optical beam pathes according to the corresponding orientation. This way certain laser pulses can be selected and amplified.

6.1.1 Polarization effects

The pulse-synchronous high voltage signal located at the EOM changes the polarization orientation. A s-polarized pulse becomes p-polarized (and vice versa).



polarization direction of seeder pulse train

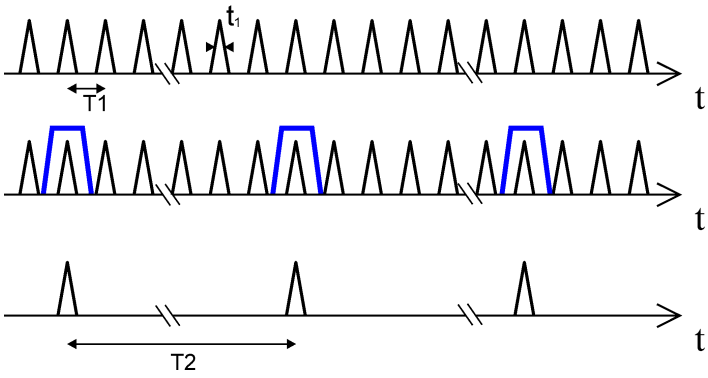
HV signals synchronized to pulses

polarization changed for selected pulses

Figure 5: correlation between HV signal and polarization

6.1.2 Function of the pulse picker

The pulse train generated in the seeder laser is displayed in the following image. Synchronously to the seeder pulse sequence high voltage signals are applied. They have a fast reaction time of approx. 5 ns. The repetition rate can be modulated up to 1 MHz.



t_1: pulse width of Seeder

T1: time between pulses, 20 ns

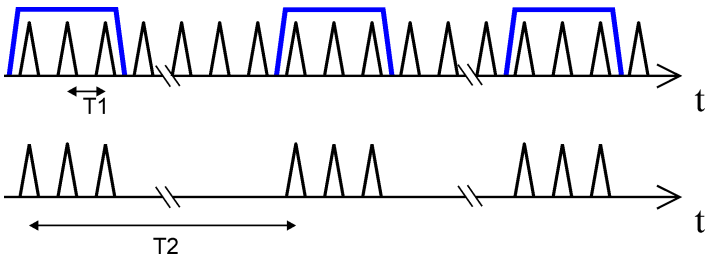
HV signal covering pulses

Selected pulses with temporal distance T2 (1/repetition rate)

Figure 6: temporal correlation of pulses

6.1.3 Burst-mode

The burst-mode describes the function to emit several adjacent pulses (out of the seeder pulse train). The temporal distance between pulses is 20 ns (according to the frequency of the seeder). The number of pulses in one group can be selected in the software and is limited to 10 pulses. The requested pulse group is repeated with the selected repetition rate.



Selection of 3 pulses (bursts) (as an example)

Pulse train is repeated with selected repetition rate (temporal distance T2)

Figure 7: Selection of several pulses out of the seeder pulse train

NOTICE!
Refer to section "RepRate Control" on page 64 for further information concerning the software settings. Suggestions how to use these signals in the application can be found in section "Principal signal configurations" on page 84.

6.2 Triggering

The trigger signal controls the optical pulse repetition rate. There are different triggers possible:

- internal trigger
- external trigger

6.2.1 Internal trigger

The pulse repetition rate is defined by the Rapid Software. In the dialog box ***RepRate Control*** the required value can be entered, refer to section "RepRate Control" on page 64. When internal triggering is selected, the input ports Trigger and Gate at the power supply's rear side are deactivated.

6.2.2 External Trigger

This function can be activated in the software and allows a way of externally defining the optical pulse-repetition rate. Therefore provide a trigger signal (5V TTL) at the BNC input ***Trigger*** at the rear side of the power supply. The laser pulses are generated with the frequency according to the TTL signal, which has to be higher than the ***Stand-by frequency***. The trigger signal shall have a switch-time of approx. 150-300 ns. We recommend to enter an ***Laser idle frequency*** value 80% to 90% of the required pulse repetition rate.

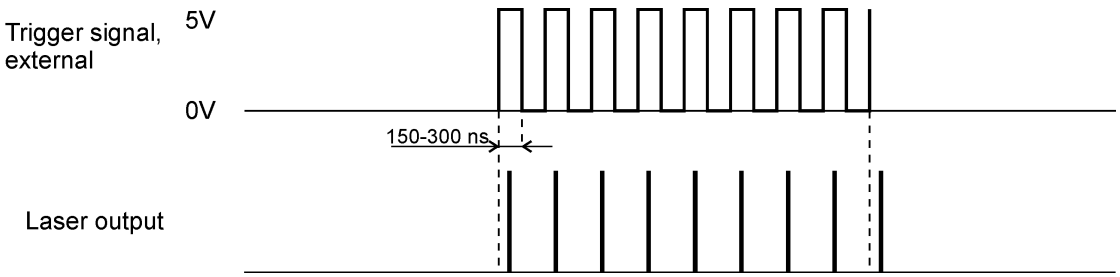


Figure 8: External TTL trigger signal

CAUTION!
Make sure to apply a valid TRIGGER signal to the corresponding interface (located at the rear side of the laser head). As long as the signal is 0, or no cable connected, the laser action is still kept alive due to the software-setting *Stand-by frequency* greater than 0.

6.3 Frequency conversion

The optical fundamental wavelength (1064 nm, invisible, IR) can be frequency converted to SHG (532 nm, visible, green). The frequency conversion into the green spectral region (Second Harmonic Generation) is generated in a nonlinear optical crystal (when ordered).

These optical elements are integrated in an additional box in front of the laser head, which is called "module" (or frequency conversion module).The integration of the module is respected during manufacturing, is individually optimized and will be delivered pre-assembled to the laser head front if ordered. Therefore the configuration needs to be ordered in advance. A subsequent integration is always possible but might interrupt the customer's workflow (it is possible that the integration cannot be done on-site).

6.4 Schematical Design

All control- and power supply units are located in a 19-inch rack. The connectors for cables and hoses are located at each rear side. In the following schematic all cable-connections are displayed. The configuration depends on the individual order and can deviate from the image.

For a machine integration these information might need to be taken into account:

- Laser fibers cannot be disconnected (neither from the laser head nor from the power supply).
- Connections between devices in the rack might be too short if the devices are taken out of the rack (or changed in its order). Some cables (e.g. HV cable) cannot be extended. Discuss this issue with your Coherent representative if necessary.
- In order to assure service and maintenance make sure that each device can be extracted out of the rack (or out of the processing-machine), that connections are long enough and can be reached for disconnecting. For example the chiller needs to be extracted to the front in order to exchange the cooling-liquid.
- The typical maximum distance between laser head and rack unit is 5.5 meters (metrical), approx. 18 feet.

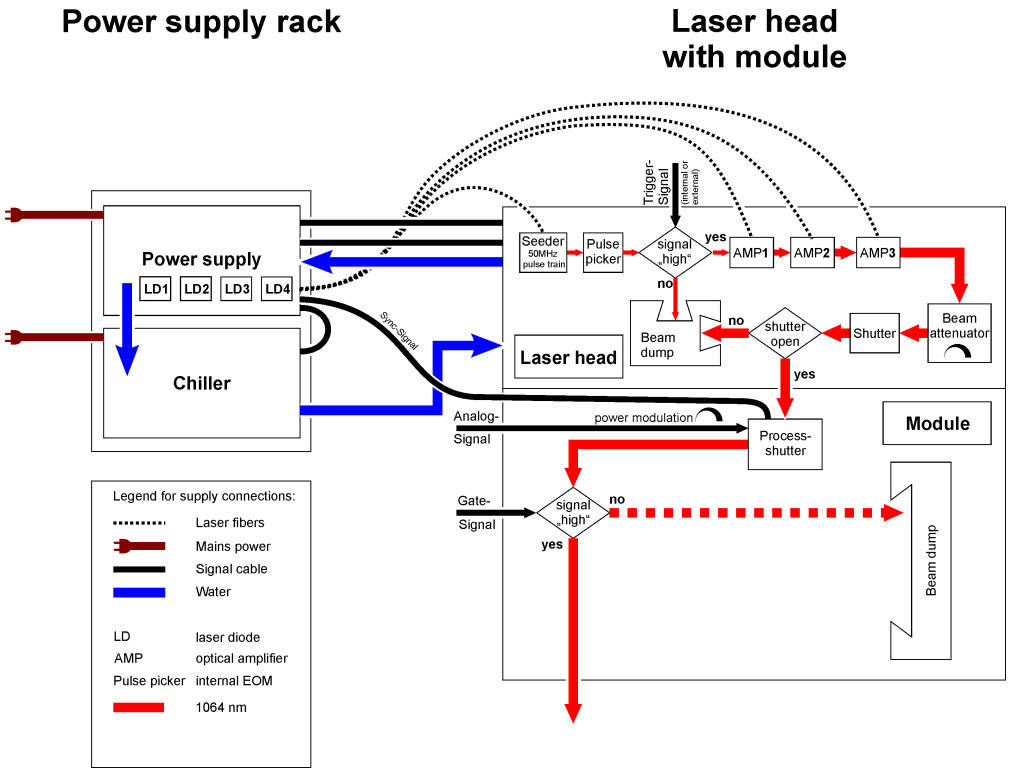


Figure 9: Schematical design of the laser system

6.5 Process-shutter

Most applications in the micro-processing require (among other specifications) a high positioning accuracy. This means emitting pulses to exactly determined time-points.

In order to offer this feature, the HYPER RAPID 50 is equipped with an implemented fast optical switch, which is capable of switching the laser beam on and off. The signals are described in the next chapter.

6.5.1 Signals for Process-shutter

The BNC-signal connectors can be found at the rear side of the laser head. The functions of the GATE as well as ANALOG are described below. Also refer to the software settings, section "Process Shutter Control" on page 66.

GATE

Provide a TTL signal in order to control (switch on/off) the optical output. 5V (high) opens the GATE, 0V (low) closes it. As long as the signal is high, the optical beam is able to emit. Choose the function ***Gate, External Control*** in the software. When the GATE is closed still a small amount of residual radiation is possible. **This function is not allowed to be used as a safety device.**

ANALOG

Provide an analog signal between 0–10V in order to influence the optical power (during processing). 10V provides full power (according to the internal beam attenuator setting). The relation between signal and optical IR-power is not linear ($P=\sin^2(U)$), refer to the diagram below. The speed of modulation is limited to 1000 kHz. In order to permanently enable full power, use the software feature ***Analog Mode, Full Power***. **This function is not allowed to be used as a safety device.**

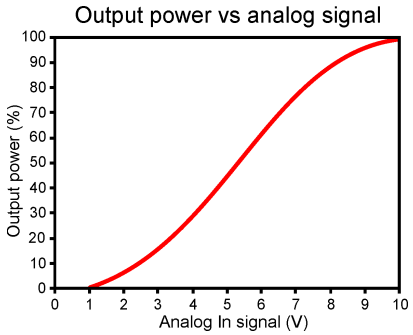


Figure 10: relation of voltage & optical IR-power

MON Monitor: output, electrical signal synchronized to the optical pulses (photo-diode signal)

SYNC IN permanently connected to ***SYNC A*** (located at the rear side of the power supply)

SYNC OUT TTL output signal in order to synchronize external devices. The time difference between signal and pulse is dependent on individual situations (run-times, etc.) and needs to be varified empirically

RFSA spectral analysis of the seeder laser.

Make sure to open the GATE and use the ANALOG input via software or by an application-signal. As long as one of the signals is 0, beam output is disabled (residual radiation still possible). As long as the GATE is permanently open (activated via software), the application signal cannot work correctly.

Closing the Gate does not completely prevent residual radiation. An amount of radiation is still emitted and might need to be guided into an appropriate beam dump.

7 Components of the system

The HYPER RAPID 50 laser system consists of the laser head and the control rack unit which contains the power supply, the chiller and optional devices depending on the order.

The three main components laser head, power supply and chiller are connected electrically as well as by a closed looped water circuit.

The HYPER RAPID 50 laser is also intended for OEM industrial applications. In this case ensure the intended and proper use of the HYPER RAPID 50 laser within the machine:

- Follow the laser safety regulations
- Provide appropriate safety circuits (e.g. interlock chains). Consult your laser safety officer (LSO) for more information
- Install external laser emission indicators (e.g. warning lamps, -signs). Make sure to select colors which remain visible through the eye protection.

7.1 Laser head

The laser head is a rugged monolithic aluminum structure which is actively temperature controlled and hermetically sealed. It consists of a

- mode-locked oscillator (seeder laser)
- fast electro-optical modulator (pulse picker)
- amplifier chain
- optionally: a second, third harmonic generator, see section "Frequency conversion" on page 42.
- and a process-shutter.

Located at the beam exit of the laser head module is a Brewster window (inclined to an angle around the horizontal axis). Due to this fact, the laser beam is linear s-polarized (E-vector vertical).

The HYPER RAPID 50 laser head contains various built-in interlocks and a safety shutter for mechanically closing and opening the laser output port. For further information concerning the interlock chains, see section "Safety devices" on page 18.

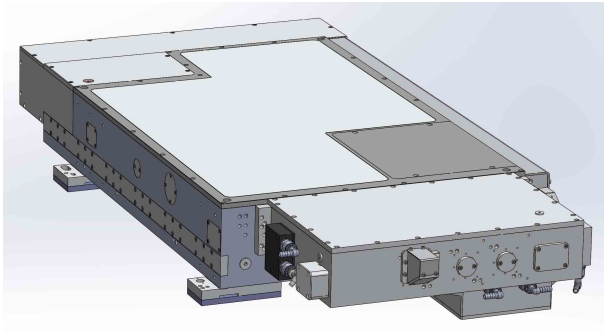


Figure 11: Perspective front view of laser head

The housing of the laser head is hermetically sealed. Ensure at all times that

- no moisture can condense on the unit
- no aggressive gases get into the case
- the laser system is protected against frost.

Such may destroy these units.

7.1.1 Front view

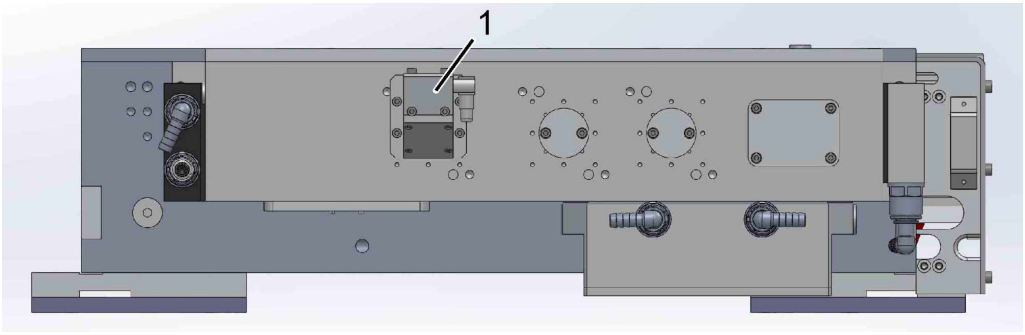


Figure 12: Front view of the laser head with adapted module

1 Beam exit port 1064 nm

7.1.2 Rear view

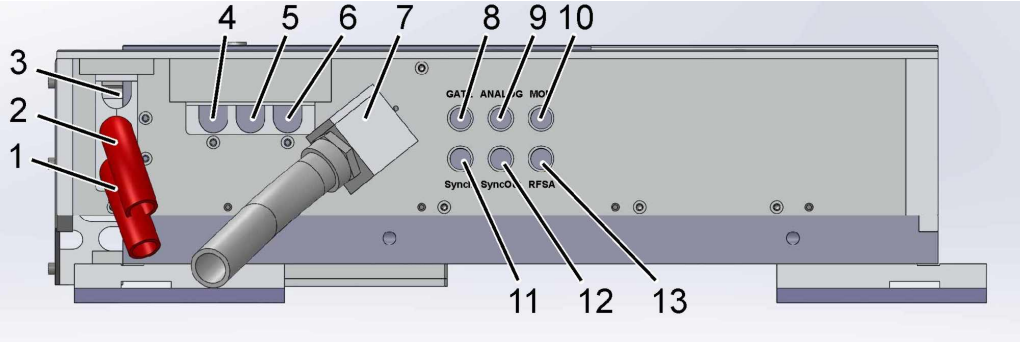


Figure 13: Rear view of the laser head

1 Chiller hose, cold water inlet from chiller
2 Chiller hose, outlet to power supply
3 High voltage power line for the pulse picker
4 S-Control
5 Timing signals
6 Interface laser
7 Umbilical with laser fibers
8 GATE: BNC plug (TTL input signal)
9 ANALOG: BNC plug (analog input signal)
10 MON: BNC plug (output, signal synchronized to the optical pulses)
11 Sync IN: BNC plug, connected to ***Sync A*** (power supply, rear side)
12 Sync OUT: BNC plug, output TTL signal for synchronizing
13 RFSA: spectral analysis of the seeder laser

7.1.3 Top view

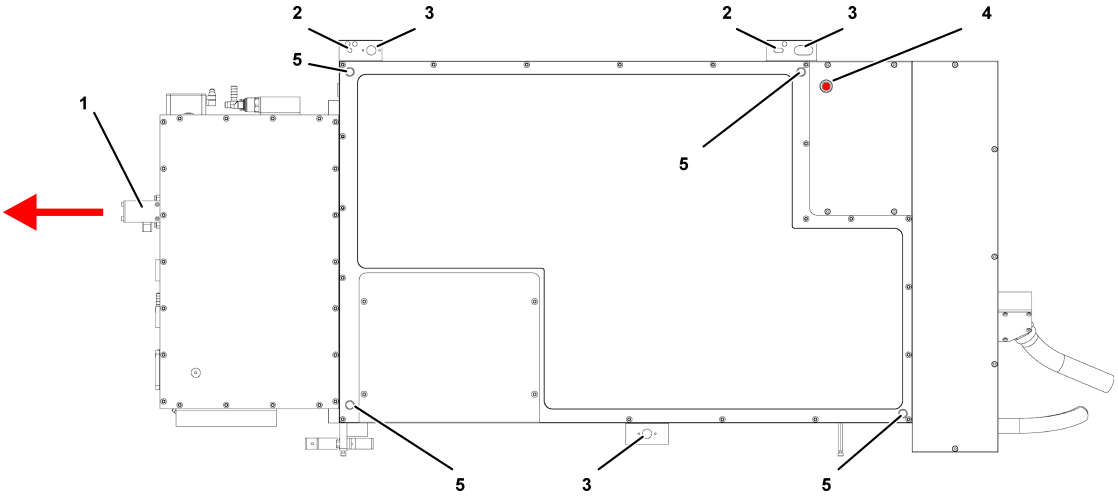


Figure 14: Top view of the laser head

1 Laser beam output

2 Pedestal, alignment pin hole

3 Pedestal, hole for screw-package

4 Lamp indicating the power status of the laser head:

- if the lamp is illuminated (red), the laser is on
- if the lamp is not illuminated, the laser is turned off.

5 Threaded hole for transportation-handles

7.2 Power supply

The system power supply contains the following integrated components:

- Power supply for the laser head and the PC monitor
- Laser pumping diodes
- Integrated PC

The power supply provides the power to operate the laser head. The integrated PC and its software program controls the laser system. The monitor, mouse and keyboard can be plugged in to the power supply's rear side.

The power supply can be integrated into a 19" customer system. Connecting the power supply to the laser head is in charge of Coherent service technicians only. Laser fibers are not allowed to be disconnected.

7.2.1 Front view

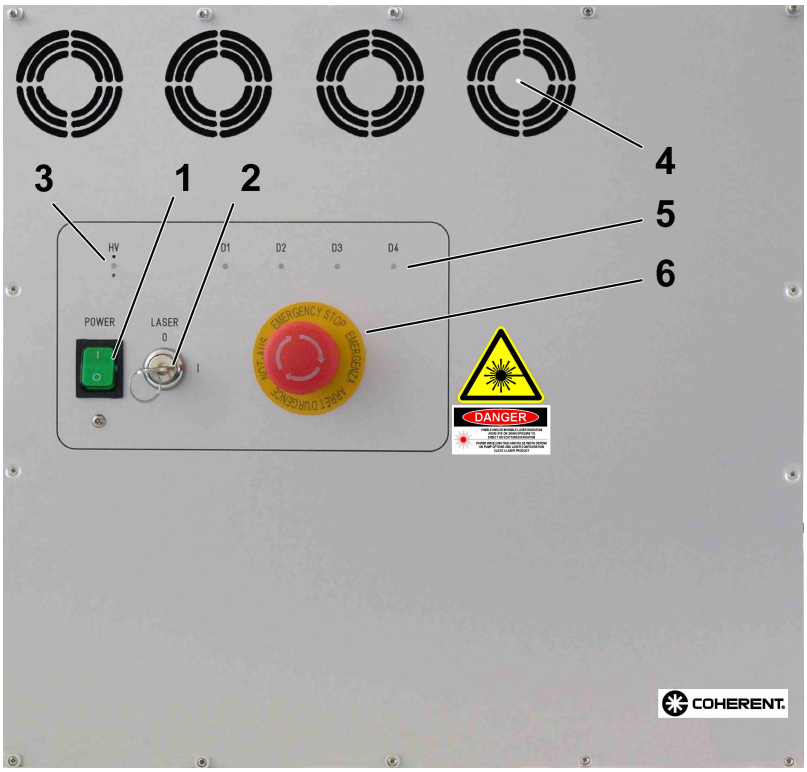


Figure 15: Front view of the power supply

1 Main power switch (On/Off); shines green, when turned on

2 Key switch (0/I), power supply can be turned on in switch position I, Key removable in position 0

3 HV LED High voltage of the pulse picker

4 Air inlets for fans

5 D1 LED pump diode of the seed laser

D2 LED pump diode of the first amplifier

D3 LED pump diode of the second amplifier

D4 LED pump diode of the third amplifier

6 Emergency stop button; hit in an emergency in order to power-off the power supply (refer to section "Safety devices" on page 18).

The LEDs are illuminated during start-up according to the following color index:

orange	Standby
green	Normal operation
red	Failure
flashing (any color)	Required temperature not jet reached or actually being adjusted

7.2.2 Rear view

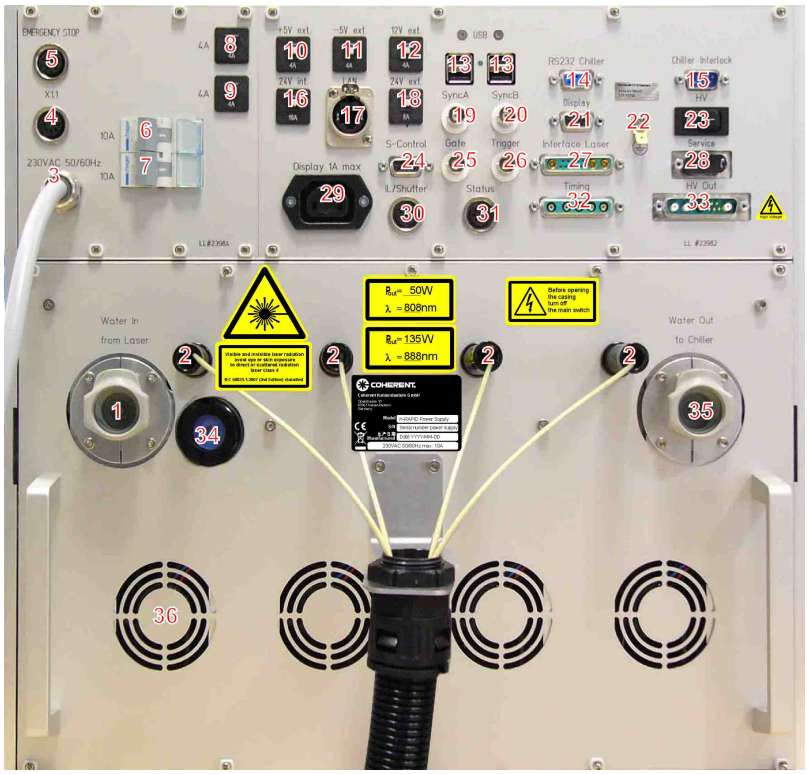


Figure 16: Rear view of the power supply

1 CPC connector water in from laser head

2 Laser diodes with fiber coupler

3 Mains power cable (230 VAC, 50-60 Hz)

4 no function

5 Output connector for emergency exit signal for a superior machine, see section "Emergency Stop" on page 56

6 Mains circuit breaker

7 Mains circuit breaker

8 Circuit breaker (4 A)

9 Circuit breaker (4 A)

10 Circuit breaker +5 V

11 Circuit breaker -5 V

12 Circuit breaker 12 V

13 USB connectors of the internal computer

14 D-Sub connector – RS-232 chiller, communication interface to chiller

15 Chiller interlock connector

16 Circuit breaker 24 V

17 Ethernet connector

18 Circuit breaker 24 V

19 Sync A: output TTL signal synchronized with laser pulses

20 Sync B: no function

21 Monitor connector (VGA)

22 Ground connection of the power supply

23 Service switch for HV power supply (remains turned on)

24 Connector to S-Control

25 no function

26 BNC-connector Trigger; The laser emits pulses according to the trigger sequence. In the software "external" must be activated.

27 Connector for laser head interface cable (including ground connection of the laser head)

28 D-Sub service connector (HV). Coherent service only

29 Power connection for the monitor

30 Output connector for shutter signal for a superior machine, see section "IL/Shutter connector" below

31 Status connector (potential-free), provides laser status signals, see section "Status connector" on page 55

32 Timing - connector for HV switch in the laser head

33 Connector for HV cable (high voltage)

34 Desiccant cartridge

35 CPC connector water out to chiller

36 Air outlet from fans

7.2.3 IL/Shutter connector

The IL/Shutter connector is located at the rear side of the power supply. It can be used to externally control the shutter, e.g. for monitoring a door (in case the door gets open, the shutter closes). The IL/Shutter connector is a 6-pin female connector. It includes 3 different functions (refer to description below).

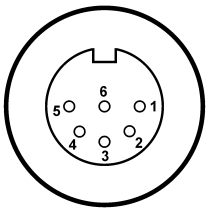


Figure 17: Interlock/Shutter connector (female)

Pin	Setting
1	Plus (+) external interlock switch
2	Shutter safety switch
3	Shutter safety switch
4	Minus (-) external interlock switch
5	Shutter push button
6	Shutter push button

External Interlock

Pin 1 together with pin 4 can be used to realize an external interlock. Opening this chain causes the shutter to close and the laser diodes to deactivate (powering-off). The power supply and the chiller remain active. In case the Interlock is being closed again, the laser diodes remain turned off. A manual switch (off and on) is not necessary. When an active circuit is connected the polarity needs to be regarded (refer to the table). Attaching a passive switch the polarity is not relevant.

NOTICE!

Take into account that the shutter is only able to be opened when the safety chain is closed. For testing purposes there is a short-cut connector (dummy) included in delivery. This one is not allowed to be used for normal operation and has to be replaced by a real safety interlock circuit.

Shutter safety switch

Pins 2 and 3: As long as these contacts are connected, the shutter can be operated. When these pins are not connected, the shutter cannot be opened or closes automatically if open. The inputs are galvanically separated.

Shutter push button

When Pin 5 and Pin 6 get temporary connected (e.g. with a push button) the shutter opens/closes. The signal is required to be a pulse (not a permanent signal-level). This function complies with a click of the ***Shutter*** in the Rapid Software. The pins are galvanically separated (potential-free).

NOTICE!

In order to implement the Interlock/Shutter circuit the adequate connector (male plug, included in delivery) can be used (alternatively: DIN 45 321 or IEC 61076-2-106). The design and implementation remains in responsibility of the customer. For further information concerning regulations of interlock chains we refer to e.g. EN11553-1 and EN60825-1. Note this as a recommendation without warranty of completeness.

7.2.4 Status connector

The Status connector is an interface on the back of the power supply, that can be used to output the present state of the laser system (laser diodes, shutter, interlock).

The Status connector is an 8-pin female connector. The circuits are potential free (galvanically isolated). The maximum allowed electrical values at the connector are 24 V and 0.5 A.

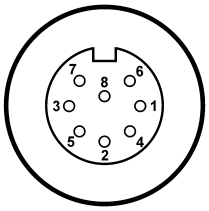


Figure 18: status connector (female)

Pin	Setting
1	Relay contact **diodes on/off**: is internally closed with pin 6, when the laser diodes are switched on (LED on power supply front side is illuminated green)
2	Relay contact **shutter position**: is internally closed with pin 4, when the shutter is open
3	Relay contact **interlock error**: is internally closed with pin 5, when an interlock error appeared (interlock circuit interrupted).
4	Refer to pin 2
5	Refer to pin 3
6	Refer to pin 1
7	No function
8	No function

NOTICE!
The Status connector is included in delivery. The implementation and usage of the signals remain in the responsibility of the customer.

7.2.5 Emergency Stop

The ***Emergency Stop*** connector is located at the rear side of the power supply and includes 2 coupled emergency Interlock signals (output). As soon as the Emergency Switch is pressed (power supply front side), both circuits open. This way one or two external interlock loops can be interrupted. The connection is designed for 230 V, 3 A max.

The socket is a 4 pin plug (female). The circuits are potential free (galvanically isolated). The corresponding connector belongs to the delivery.

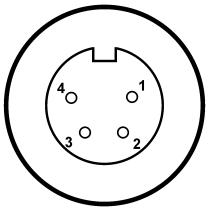


Figure 19: emergency stop socket (female)

Pin	Description
1	Relay contact is internally closed with pin 2, as long as emergency switch (front side) is not activated.
2	refer to pin 1
3	Relay contact is internally closed with pin 4, as long as emergency switch (front side) is not activated.
4	refer to pin 3

7.3 Chiller

In order to operate the laser, a chiller is necessary. Coherent Kaiserslautern GmbH offers two different chiller types:

Water-to-Air Chiller

This chiller only needs an adequate power connection. In addition it must be ensured that the discharged air of the cooler is conducted.

Water-to-Water Chiller

This chiller needs an adequate power connection and an additional water circuit (primary circuit), which is connected to both CPC-connectors at the rear side of the chiller. The chiller controls the primary water circuit via a valve. For more details concerning the specifications, refer to section "Specifications" on page 37.

In case the voltage deviates from 230 V, an external transformer is necessary in order to operate the chiller, the power supply and optionally additional devices. In this case, the chiller is not allowed to be powered without the transformer.

CAUTION!
Ensure the correct mains voltage.

The water flows from the chiller (blue label, chiller rear side) into the laser head, then through the power supply cooling the laser diodes and back into the chiller (red label, chiller rear side). The water circuit is visible in the image below. Hoses are connected via CPC-fasteners. The hoses at the laser head cannot be unplugged.

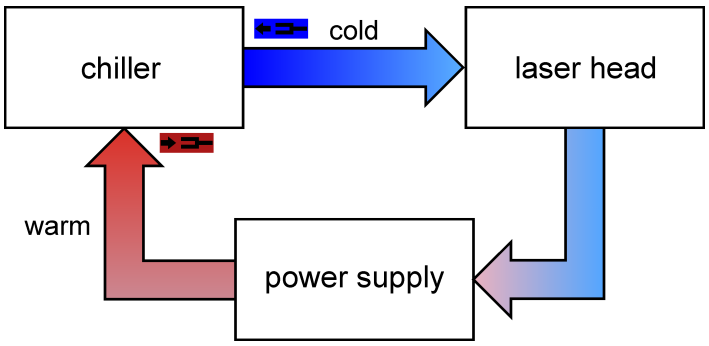


Figure 20: Coolant circuit of the HYPER RAPID 50 laser

The chiller is switched on automatically when the HYPER RAPID 50 software is started. The temperature of the chiller is also set or changed via the laser software.

Initially stabilizing the water temperature can take approximately 20 min.

Verify that the coolant in the chiller is at a proper level. Preventive maintenance for the chiller (changing water and filter at the same time) is periodically mandatory (see section "Maintaining intervals" on page 89). Refer to section "Maintaining the chiller" on page 90 for maintenance instructions.

In order to ensure enough heat exchange (in case of a water to air system) make sure that there is sufficient amount of space behind the chiller (>0.5 m) (>20 inches). Also the air circulation / ventilation and fresh air supply should not be constricted.

NOTICE!
For more information refer to the chiller manual.

7.4 Control unit rack

The rack includes all necessary power supplies and the chiller. Various rack heights are available. The rack equipment depends on the order and could deviate from the picture below.

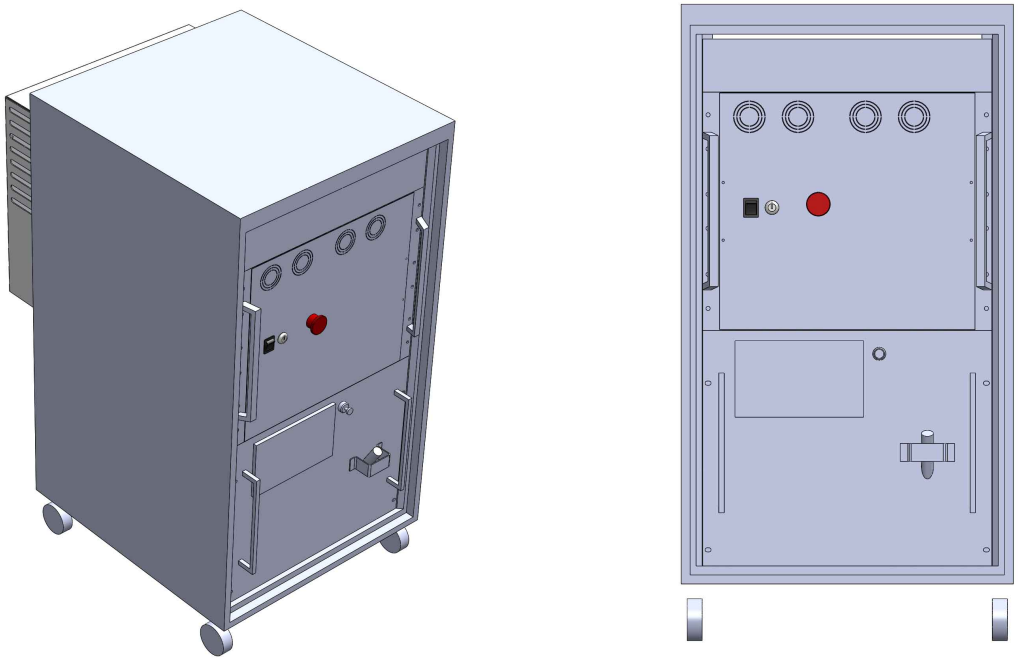


Figure 21: Control unit rack

8 Rapid Control software

The HYPER RAPID 50 software is pre-installed on the integrated computer of the power supply. In order to control the laser system with the integrated PC, a keyboard and mouse can be attached to the USB ports on the rear side of the power supply.

The laser control software can act directly via "graphical user interface (GUI) or over a client / server connection via an Ethernet cable. For this a DLL (dynamic link library) exists, see section "Preparing external control" on page 75.

8.1 Main window

The Rapid Control software starts with the main window in which the major laser settings are displayed or accessible via the menu. The menu contains the entries ***File***, ***Tools***, ***Service***, ***Test*** and ***?***. The functions are described in this chapter.

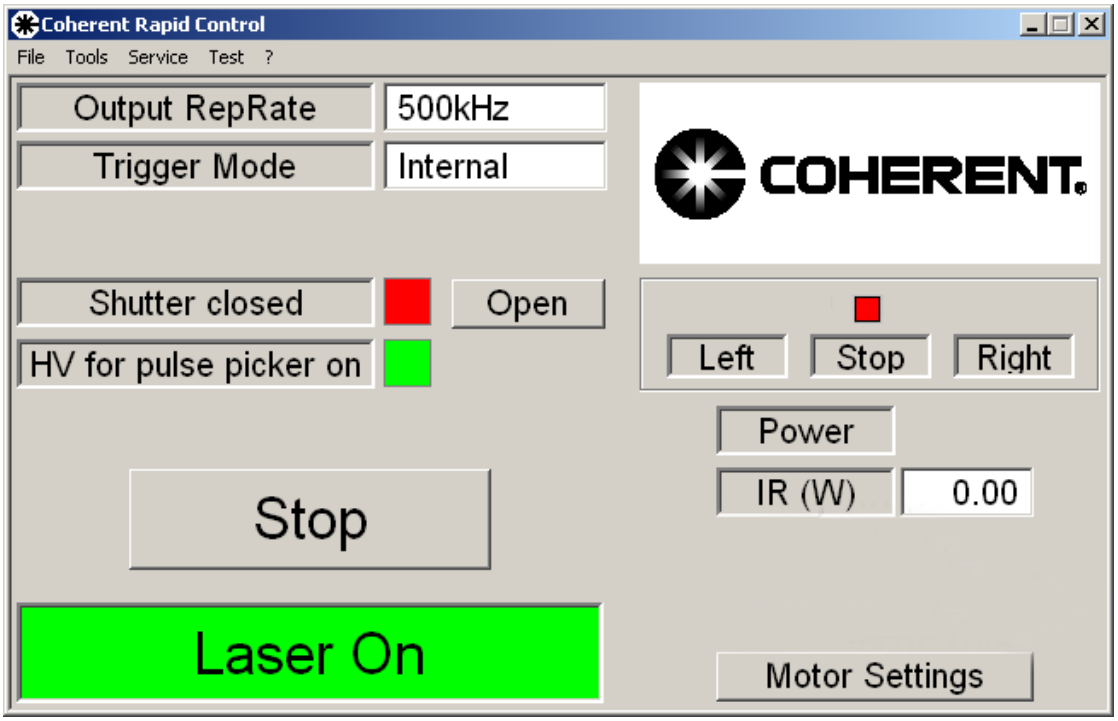


Figure 22: Laser control software: main window

Output RepRate

Displays the repetition rate

Trigger Mode

Displays the present trigger mode. In order to switch the mode refer to section "RepRate Control" on page 64. The following modes are possible:

Internal: The laser is triggered internally

External: The laser is triggered externally.

Switching between internal and external triggering takes approx. 10 seconds. During this time there is no laser activity.

Shutter open/closed

Displays the present state of the shutter. The ***Open / Close*** button toggles between both states. Each state is color coded:

Red	The shutter is closed, no laser beam is emitted.
Green	The shutter is open and the laser beam is emitted.

HV for pulse picker on/off

Displays the present state of the high voltage drivers for the pulse picker.

Red	High voltage for the pulse picker is off (or initializing), the laser is not ready to work.
Green	High voltage for the pulse picker is on, the laser is ready to work.

Left, Stop, Right

Displays the variable attenuator position. The red box above ***Stop*** symbolizes that the attenuator is standing still. Any moving action will be displayed with an indicator above the direction field. In order to activate the attenuator (and reduce the optical power) refer to ***Motor Settings*** (below). The motor position is being saved when the laser gets turned off and reloaded during startup.

Power

Displays the optical power for the corresponding wavelength (IR). In order to change the power, open the dialog ***Motor Settings***. When the laser is turned on the last position of the variable attenuator will be relocated. Note that the internal power measurement has an accuracy of 5%. Measuring more exact can only be done externally by the customer.

Start/Stop

Switch for turning on/off the laser.

Laser On/Off

Displays the present laser state.

Red	The laser is off and not ready for work.
Green	The laser is turned on and ready for work.

Motor Settings

Opens the ***Motor Settings*** dialog box, see section "Motor Settings" below.

8.1.1 Motor Settings

The ***Motor Settings*** dialog box displays the present position of the attenuator. The attenuator controls the optical power of the laser system. In order to keep the beam parameters most constant, the laser runs with constant current and maximum power. Decreasing the beam power takes place by changing the position of the so-called variable attenuator. The functions are described in this chapter.

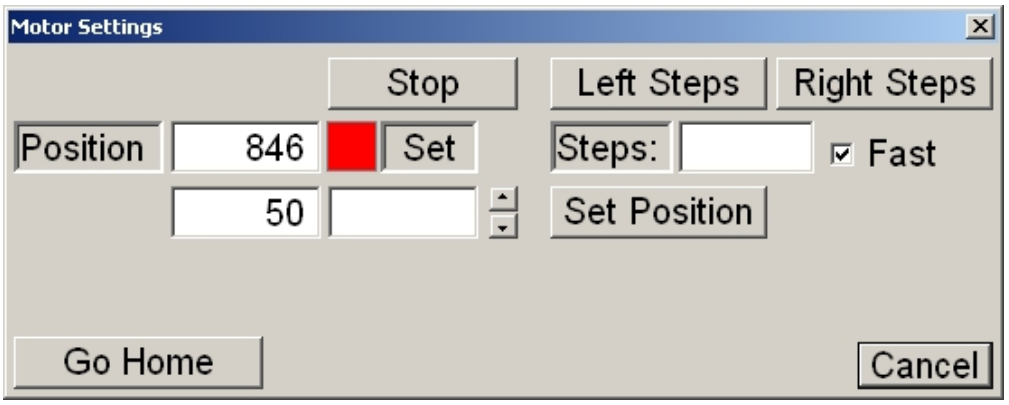


Figure 23: Motor Settings dialog box

Left Steps/Right Steps

Moves the motor counter clockwise / clockwise with the in ***Steps*** defined number of steps. ***Fast*** enables the movement with increased speed.

Position Displays the present position of the attenuator. The range is between 0 and 1692 steps. (In case a high resolution attenuator was ordered the range is between 0 and 10800). The box on the right indicates a movement (green) of the attenuator or red when the attenuator does not move. Below this field the position is displayed in percent. The empty area on the right enables the entry of a requested value in percent (0-100%). It also can be modified by clicking the arrow up/down. The impact on the power is not linear. Entering a value (in steps or in percent) needs to be activated with ***Set Position***. With ***Stop*** an executed movement can be interrupted. An actual position is going to be saved when the system gets turned off and reallocated after turning on the laser.

Stop Interrupts the active movement

Go Home Moves the attenuator to the default power position

Cancel Cancels the dialog and closes the window

8.2 File menu

The ***File*** menu contains the following command(s):

Open Opens and loads individual settings for the repetition rate control, see section "RepRate Control" on page 64.

Save Permanent Allows to save the present settings of the repetition rate control in the backup folder `C:/Rapid/Rapid_backup`. The previous parameter set will be overwritten.

Restore Restores the previously saved settings of the repetition rate control.

Quit Closes the Rapid Control software.

8.3 Tools menu

The ***Tools*** menu contains the following commands:

Laser Data Opens the ***Laser Data*** dialog box, refer to section "Laser Data" on the facing page.

RepRate Control Opens the ***RepRate Control*** dialog box, see section "RepRate Control" on page 64.

Process Shutter Control Opens the ***Process Shutter Control*** dialog box, refer to section "Process Shutter Control" on page 66.

Seeder Laser Control Opens the ***Seeder Laser Control*** dialog box, refer to section "Seeder Laser Control" on page 68.

Amplifier Laser Control Opens the corresponding ***Amplifier Laser Control*** dialog box, refer to section "Amplifier Laser Control" on page 69.

8.3.1 Laser Data

The ***Laser Data*** dialog box displays the status information of the HYPER RAPID 50 laser. The displayed information are dependent on the system configuration.

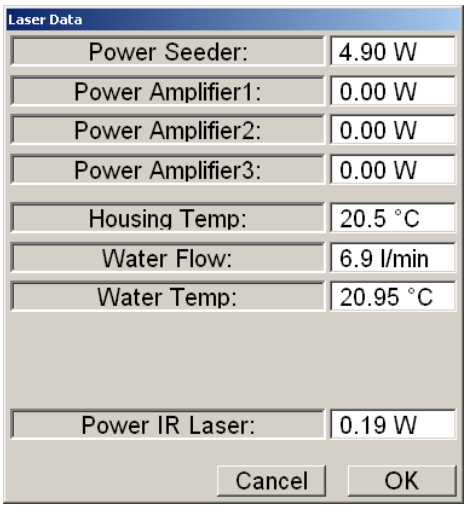


Figure 24: Laser data dialog box

Power Seeder Displays the measured power of the seeder laser

Power Amplifier1 Present power of the first amplifier

Power Amplifier2 Present power of the second amplifier

Power Amplifier3 Present power of the third amplifier

Housing Temp Present temperature of the laser head housing

Water Flow Present flow rate of the chiller

Water Temp Present temperature of the chiller

Power IR Laser Actual IR power; measured by internal photo diodes, displayed only if a frequency conversion module is present.

8.3.2 RepRate Control

In the ***RepRate Control*** dialog box you can configure the pulse repetition frequency. The present settings can be saved with ***File/Save***. In the following you can get a description of all functions:

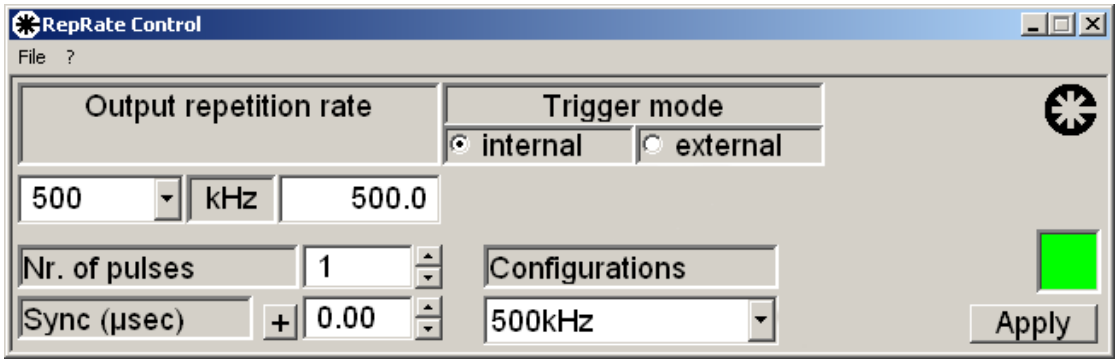


Figure 25: RepRate Control dialog box

The dialog box contains the menu entries ***File*** and ***?***.

The ***File*** menu contains the following commands:

Save Configuration

Saves the present settings of the repetition rate control. Choose a name and press ***OK***.

Set Start Configuration

Defines the configuration which is supposed to be used on startup. Choosing this function shows a drop down list of all saved configurations. The default setting is 500 kHz.

Hide

Minimizes the dialog box to the system tray without closing the window.

The ***?*** menu contains the ***Info about RepRate Control*** command that opens a dialog box, in which the version of the repetition rate control software is displayed. Close the dialog box with ***OK***.

The dialog box offers the following options:

Output repetition rate

Drop down list of selectable repetition rates. Alternatively the requested frequency can be entered into the left dialog field. Right next to it the display window shows the effectively activated pulse repetition rate. Press ***Apply*** in order to activate a new entry.

Trigger mode

Switching between internal and external trigger takes approx. 10 seconds. During this time no material processing is possible. The time between switching is indicated by a red box.

- ***internal***: The repetition rate is created internally.
- ***external***: The repetition rate follows the frequency defined by the TTL signal present at the BNC connector at the rear side of the laser power supply. The entry ***Stand-by frequency*** appears. This defines a minimum frequency in case the TTL signal falls out of range (or no signal is present). It is recommended to set the Stand-by frequency approx. 10% lower than the pulse-repetition-rate in order to make sure that the laser remains active.

Nr. of pulses

Defines a pulse group with 1 to 10 pulses which have a time distance of 20 ns (related to the frequency of the Seeder). The pulse group is repeated with the repetition rate defined in the dialog (e.g. 500 kHz). This function is called burst mode. Press ***Apply*** to activate changes.

Sync (µsec)

Output signal relative to the pulse group. The prefix "+" in front of the dialog indicates that the signal is generated after the optical pulse. Change the sign (mouse-click) to "–" in order to get the signal before the output. Refer to section "Rear view" on page 52 in order to find the location of the connector. Press ***Apply*** to activate changes.

The absolute value needs to be determined empirically due to individual signal running times. The minimum value is -0.1 µs. The signal width is approximately 120 ns and represents the optical pulse-repetition rate independent of the ***Nr. of pulses*** (bursts).

Configurations

Offers a drop down list of the saved parameter sets. In order to activate a new configuration, choose the requested one and press ***Apply***. Note that on "Start-up" the configuration selected in ***Set Start Configuration*** is used.

The colored box indicates the functionality of the trigger:

red		trigger is not ready or laser is turned off.
green		trigger is operational

Apply

Entered or changed values need to be activated by pressing ***Apply***. Multiple values can be modified consecutively and get confirmed this way.

Alternatively press ***F9*** in order to activate the ***Direct apply***. When activated drop down values get active without the need of pressing "Apply". The activation is visible by a yellow dialog box. Press F9 again for deactivation of the Direct apply.

NOTICE!
More information concerning the Trigger can be found in **section "Pulse picking" on page 39.**

8.3.3 Process Shutter Control

Dialog (***Menu / Tools***) in order to define the features of the process shutter. In case of an application-signal (coming from a scanner-system, x-y-table, function-generator, etc.) choose the entry ***External Control*** and apply the signal. The function ***Continuous High*** opens the Gate and enables the beam output permanently (switch on/off not possible).

In case the optical beam power is supposed to be modulated during processing, choose ***External Control*** and apply an analog (0-10V) signal to the connector ***Analog*** (laser head, rear side), otherwise choose ***Full Power***.

Use the function ***Modulo Divider*** in order to decrease the output repetition rate. The internal repetition rate and thus the pulse energy remains unchanged. The integer number indicates a counter of pulses (2: refers to every second pulse out of the output RepRate (defined in the dialog ***RepRate Control***), 3: every third pulse, etc.). The resulting RepRate is displayed below. This function is exclusively available with ***External Control***.

The definitions are saved and reused after start-up.

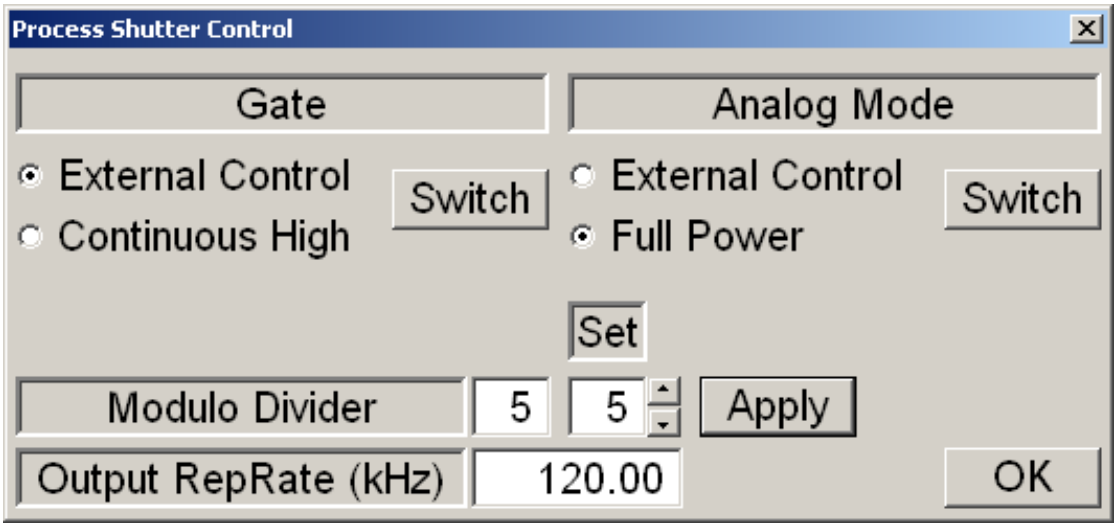


Figure 26: Process-Shutter Control

Make sure to open the GATE and use the ANALOG input via software or by an application-signal. As long as one of the signals is 0, beam output is disabled (residual radiation still possible). As long as the GATE is permanently open (activated via software), the application signal cannot work correctly.

8.3.4 Seeder Laser Control

The ***Seeder Laser Control*** dialog box contains the information concerning the seeder laser described in this chapter. Only the Coherent Service is able to adjust the settings.

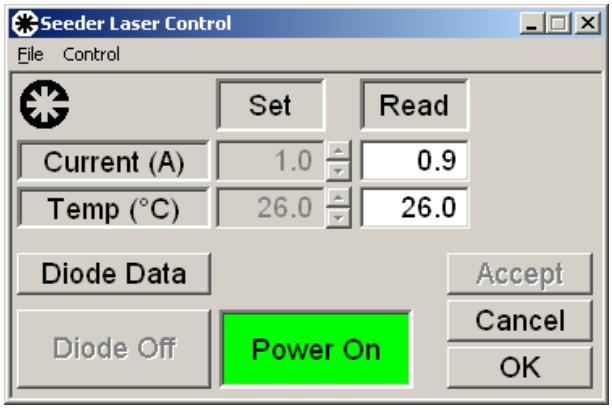


Figure 27: Seeder Laser Control dialog box

The dialog box has a menu bar with the entries ***File*** and ***Control***.

The ***File*** menu contains the command ***Exit***, that closes the dialog box.

The ***Control*** menu contains the following commands:

Diode Data

Opens the ***Diode Data*** window, that displays the present settings for the related diode, see section "Diode Data window" on the facing page.

Diode On

Toggles between the diode states. Each state is color coded:

green		the diode is turned on
red		the diode is turned off

Current (A)

Displays the present current.

Temp (°C)

Displays the present temperature in degrees Celsius. The temperature values are color coded:

- white: temperature is in normal range
- blue: temperature is too low. Wait until required temperature has been reached.
- red: temperature is too high. Wait until the laser is cooled down and on working temperature.

Power On/Off

Displays the diode laser state.

8.3.5 Amplifier Laser Control

The ***Amplifier Laser Control*** dialog box displays the same information like the dialog box for the Seeder Laser Control (refer to the chapter before) concerning the corresponding amplifier diodes. The settings are exclusively adjustable by the Coherent-Service.

8.3.6 Diode Data window

The ***Diode Data*** output window displays the present settings for the selected diode (seed laser or amplifier). It is reachable by choosing ***Control*** in the corresponding ***Laser Control*** dialog box.

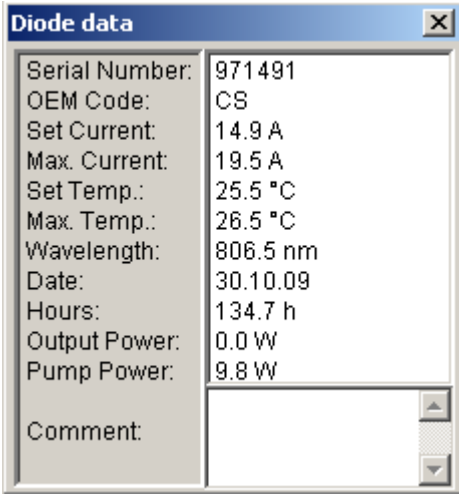


Figure 28: Diode Data output window

Serial Number Serial Number of the selected diode

OEM Code Service information

Set Current Requested current of the selected diode

Max Current Maximum current for the selected diode

Set Temp Requested temperature of the selected diode

Max Temp Maximum temperature for the selected diode

Wavelength Present wavelength

Date Date when the diode was mounted into the laser

Hours Operating hours

Output Power Present power of the selected diode

Pump Power Set value of the selected diode

Comment Comment

8.3.7 Power regulation

The function ***Power Regulation*** actively stabilizes the output power by controlling the variable beam attenuator. In order to turn on the function open the ***Tools Menu*** in the GUI and choose ***Power Regulation***. Select the check-box and enter the requested optical power (in Watt). Note that the value is an internal photo-diode reading (before the pulse picker). Therefore the entered value has to be larger than the optical output power. If the value cannot be reached, the system will respond with an error. In this case decrease the entered value. Press ***Apply*** to activate.

The relevant photo-diode reading can be found in the GUI ***Laser Data*** value ***Power IR Laser*** or requested via DLL with the command `IRLaserPowerGet()`.

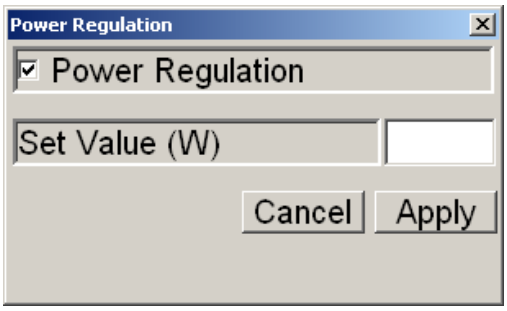


Figure 29: Power Regulation

The status of the function is saved and reloaded on GUI start-up, indicated by the dialog ***Regulation Active***. A movement is indicated by a green arrow above the dialog ***Left*** or ***Right***. As long as the power regulation is activated, direct control of the variable attenuator (optical output power control) is disabled. Deactivate power regulation in order to control the variable attenuator via the ***Motor Settings***-dialog or the ***Left*** and ***Right*** buttons. In order to turn off the function, choose ***Tools/Power Regulation***, deselect the check-box and confirm with ***Apply***.

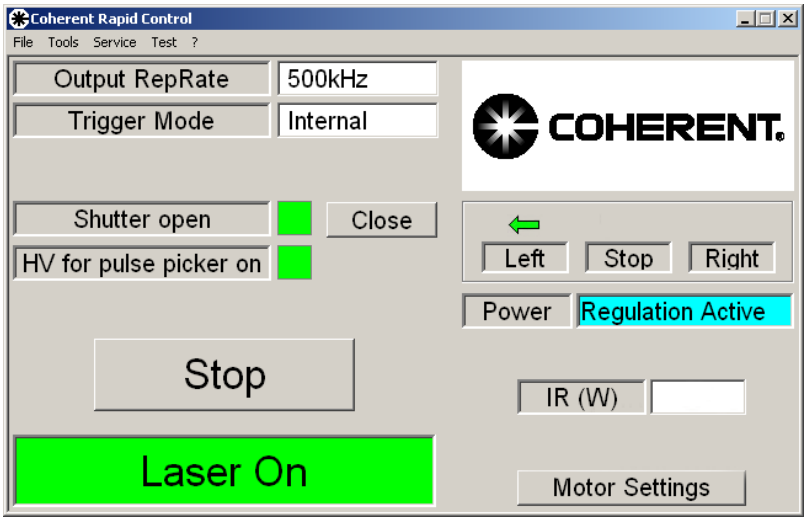


Figure 30: GUI main window with power regulation active

Instead of using the GUI this function also can be activated via DLL.

- `PowerRegEnable(true)` activates `PowerRegEnable(false)` deactivates the regulation
- `IRPowerSet("value")` defines the requested IR power in Watt (replace "value" by number)

Following DLL commands are related to this function, refer to the external document "DLL Specification" for further details:

Command	Description
`PowerRegulationEnable()`	Enables / diables the power regulation
`PowerRegulationEnableGet()`	Populates the reference with the enable state of power regulation
`PowerRegulationProcessingGet()`	Populates the reference with true while the power regulation is processing (at the time of request), with false otherwise
`IRPowerSet()`	Sets the IR power of the power regulation to the desired power level
`IRSetPowerGet()`	Populates the reference with the IR set power level of power regulation

During warm-up time of the system (e.g. on system start-up) the power regulation is deactivated. The default start-time of the active stabilization is 30 minutes after system-start.

Also after opening the shutter, the regulation waits for 30 seconds (default) in order to let the measured value stabilize.

8.4 Service menu

The ***Service*** menu contains the following commands:

Enter Service Password

Opens the ***Service Password*** dialog box in which you can enter the service password. The service password enables advanced access for the Coherent Service personnel.

Chiller Maintenance

Opens the ***Chiller Maintenance*** dialog box. After changing coolant and filter (recommendation to do both at the same time) you can reset the time counter by clicking the dialog ***Chiller Water Changed***. This action needs to be confirmed in a second dialog. For further information concerning the maintenance refer to section "Maintaining the chiller" on page 90. Resetting the counter can be checked and is described in the section "? menu" below.

8.5 Test menu

The ***Test*** menu contains the following command:

Set Test Params

Opens the ***Set Test Parameters*** dialog box in which you can set a time value to define intervals of saving laser specific logging parameters. The default value is 600 seconds. The button ***Disable*** deactivates the recording (***Enable*** activates it). The Logging file is called `xxxx_Data.lll` (xxxx is replaced by the serial number of the laser) and can be found in the directory `C:/Rapid/Rapid_Main/Main_Program`. Opening the file is possible with any editor, preferably with a table calculation program.

8.6 ? menu

The ***?*** menu contains the following commands:

Info about Rapid Control

Opens the ***Info about*** dialog box, in which the software-version-information is displayed.

Create Status report

Creates a status report file with actual information and settings of the laser and saves it on the desktop (Windows start-window) of the system internal computer.

Maintenance Information

Opens the maintenance information window, in which the following operation counters are displayed:

- ***change chiller water*** number of days, after which a coolant & filter change is necessary (count-down, starting at 183 days)
- ***operating hours of the Seeder diode***
- ***operating hours of the amplifier diodes***
- ***actual absorber spot*** (refer to section "Starting S-Control" on page 96)
- ***absorber spot operating hours***
- ***remaining hours of actual absorber spot***.

8.7 Software Info

The Rapid Control software monitors (if necessary) the condition of the HYPER RAPID 50 laser via message box:

Status	Description
Start-up	Thermalisation can take up to 30 minutes (depending on the environmental conditions) after turning on the HYPER RAPID 50 laser system.
OK	The HYPER RAPID 50 laser starts without any messages.
Warning	A dialog window shows the corresponding warning. It has to be regarded and a maintenance should be scheduled (e.g. performing S-Control). This message appears once during start-up.
Alarm	A dialog windows shows the corresponding alarm. It is required to remove the cause of error. S-Control should be started in order to perform a maintenance cycle. Alternatively Coherent Service can be contacted. This message periodically appears and shall not be ignored, see section "Software maintenance" on page 95.
Error / Shut down	The laser does not produce enough power or has another problem which causes a complete shut-down of the system. S-Control has to be started. Alternatively contact Coherent Service.

9 Preparing external control

Beside the Rapid Control software installed on the integrated power supply's PC the laser system can also be controlled via DLL. If the system is part of a machine, it thus can be controlled via network.

For controlling the HYPER RAPID 50 laser from an external PC a server application within the power supply and a client application on the external PC are necessary to control the laser system:

- On the power supply the server application `LL_Server.exe` is necessary, which receives and converts the instructions over the LAN connection. After the server application is started it checks for a connection with the client application over the network. It is recommended to start the server application automatically via autostart.
- The Client application has the name `RapidClient.dll` and must be installed on the external PC (not included in delivery). All commands are described in the "Rapid DLL Specification" manual located on the Documentation-CD.

When using a firewall on the external PC, ensure that the specified communication port is open. This communication port is set in the `ConfigN.ll2` configuration file for the server and the client application.

NOTICE!

How to install and configure the client application on the external PC is described in section "Configure the client application" on the next page. After the configuration you can test the connection with the `Rapid_DLLtest.exe` program, see section "Testing the client application" on the next page. Further information can be found in section "External control" on page 82.

9.1 Installation of the Server application

The server application is already installed on the integrated computer of the power supply.

9.2 Configure the client application

- Copy the `Rapid_Client` directory from the CD to the `Rapid` directory of the external PC. Alternatively you also can choose a different directory name as long as all client files are stored in the same folder.
- Open the `Rapid_Client\ConfigN.ll2` file in notepad (or any editor)
- Enter the ***ServerIP*** address of the integrated computer (the address can be found in ***LAN connections / properties / Internetprotocoll (TCP / IP)***).
- Enter the ***Port*** number, which was defined during configuration of the Server, default value: 1010.
- Save and close file `ConfigN.ll2`.

Open the `Rapid_Server\ConfigN.ll2` file (located on the integrated Server) if the communication is requested over a different port. Enter a new port number and transfer the same number into the `Rapid_Client\ConfigN.ll2` file (Client Computer).

9.3 Testing the client application

You can test the client application on the external PC with the `Rapid_DLLTest.exe` test program. This program resides in the `C:\Rapid\Rapid_Client` directory (and in the backup folder of the delivered documentation-CD). We recommend to start the program on the client computer in order to test the network connection as well as the transmission of commands.

NOTICE!

Note that the simulation program (without an existing laser system) will not provide real values. Functions are able to be simulated independent from the potential system configuration.

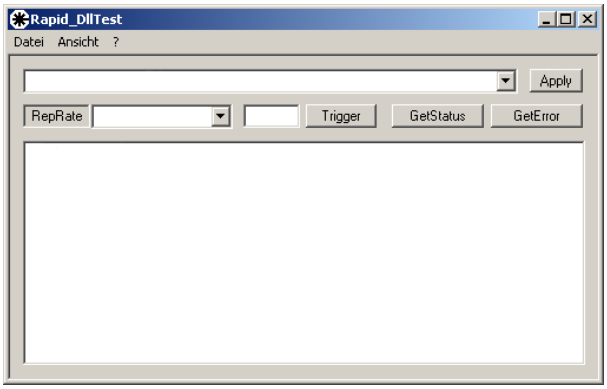


Figure 31: Rapid_DLLTest program

Choose a command from the drop-down list and press ***Apply*** in order to activate the function.

GetStatus delivers the status of the laser.

GetError delivers a text string, which describes the corresponding error in case of appearance. If a command was sent and created an error, the feedback is displayed automatically in the description area of the DLLTest program. We recommend to program an interface in a similar order of commands: In case a command creates an error, the return value will be -1 (also refer to "DLL specifications"). Then the error should be requested by the command `ErrorGet` and can be displayed to the user.

RepRate: By choosing the command ***Pulse Frequencies Get*** (out of the drop-down list above RepRate) a list of all possible repetition frequencies appears right next to the RepRate entry. On the other hand using the command ***Pulse Frequency Get*** will display the actually set repetition rate. In order to change the selected repetition rate, choose an entry out of the drop down list, choose the command ***Pulse Frequency Set*** and press ***Apply***.

In order to transmit a parameter use the field right next to the RepRate drop down window. For example ***IR Power Level Set*** expects the delivery of the power in Watt.

The entries ***Datei*** and ***Ansicht*** in the menu do not have a function.

The definition of the trigger expects the delivery of several parameters. In order to simplify this procedure, open the dialog ***Trigger***.

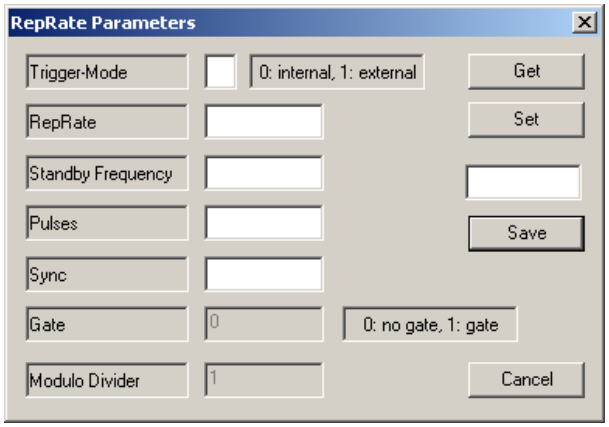


Figure 32: Pulse Trigger Setup dialog

Parameters you find in here correspond with the ones from the commands `Pulse Trigger Setup Set` and `Pulse Trigger Setup Get`.

Trigger-Mode expects the entry: TRIGGER_INTERNAL or TRIGGER_EXTERNAL.

RepRate defines the pulse repetition rate in kHz

Standby Frequency defines the rep.-rate when the laser is inactive (e.g. trigger signal out of range)

Pulses defines the number of pulses (max. 10 per burst)

Sync defines the time of the sync-output signal relative to the optical pulse.

Gate no function

Modulo Divider no function

After entering all parameters, press ***Set*** to transmit and activate the data set. An actual data set can be requested by pressing ***Get***.

10 Operation

In this chapter the mainly used operations to control the HYPER RAPID 50 laser are described. There are two possible types of controlling the laser:

- direct control
- external control

10.1 Prepare to start

Make sure that signal cables are connected before the turn-on sequence is initialized (in order to prevent false signals). Also all interlock chains have to be closed, otherwise the system might not turn on or the shutter might not open (refer to the corresponding chapters: key switch, emergency stop, IL/Shutter connector).

WARNING!
Previous chapters, installation procedures and especially "Safety issues", must be read and fulfilled. The laser beam must be adequately protected, covered and guided to a defined place (e.g. a beam dump for testing purposes).

WARNING!
Laser - protective clothing as well as adequate eye protection must be worn. Involved persons must be advised of danger.

10.2 Direct control

Via the software installed on the power supply the laser system can be controlled directly.

10.2.1 Starting the laser

Make sure that laser safety is fulfilled, and section "Prepare to start" on the previous page is regarded. To start the HYPER RAPID 50 laser, proceed as follows:

- Make sure that the HV switch (located on the rear side of the power supply) is turned on (and can always remain in the "on" position).
- Turn the key switch on the power supply (front side) to the ON position.
- Switch on the main switch of the power supply. The switch shines green. The power supply starts a self test and then initializes the laser head. The LEDs on the power supply blink orange. The integrated PC is loading the Windows operation system.
- The chiller gets turned on automatically by the power supply.
- Turn on the monitor of the integrated PC.
- On the integrated PC's desktop start the Rapid Control software with a double click. The main window opens, see section "Main window" on page 59.
- The LEDs of the power supply will shine orange to indicate the standby mode and the system ready state.
- When the LEDs on the power supply shine orange, select ***Start*** in the Rapid Control main window. First the seeder laser, then the amplifiers and the delay generator are turned on. The LEDs on the power supply shine green.
- Refer to the software function ***Gate*** and ***Analog*** to define required functionality. Without these correct settings, beam output might be disabled.
- Select ***Open*** to open the shutter and emit the laser beam. Before this is allowed make sure that laser safety is fulfilled. The beam has to be guided to an adequate position (or into a beam dump for testing purposes).

It is also possible is to turn on all power supplies at the same time (make sure to provide adequate switching devices, cable sizes and fuses designed for the corresponding total amount of power and inrush-current/max. current (refer to identification label located on the power supply).

10.2.2 Stopping the laser

To stop the HYPER RAPID 50 laser, proceed as follows:

- Close the shutter
- In the main window of the Rapid Control software select ***Stop***
- Close the main window, see section "Main window" on page 59
- Shut-down the internal PC within the power supply (Start/Shutdown)
- Switch off the main switch of the power supply. The power supply shuts down the laser head and the integrated PC.
- Turn the key switch on the power supply's front side to the OFF position
- Turn off the monitor of the integrated PC

The turn-off procedure just happens in opposite order compared to the turn-on procedure. Alternatively it is also possible to turn off all power supplies at the same time.

10.3 External control

In order to operate the HYPER RAPID 50 laser in a superior machine, it is possible to transmit external commands via network (DLL); refer to the external document "DLL specification" located on the Documentation-CD. Note that some commands are optional and dependent on system configuration. They are explicitly indicated in the external document. Some commands are dependent on the number of delay cards (hardware configuration). This can be requested by sending `GetDelayGeneratorConfig(integer)` (sending just once). The integer variable contains the value 1,2 (or -1 in case of an error). The return value of the function is 0.

10.3.1 Prerequisites

- Server application is configured and running (on the integrated PC).
- Client application (customer-specific program or `RapidDLLTest`) is installed and configured (on the external PC).
- Network is configured and functional. The communication port numbers are defined (on both sides).
- The laser is started.

10.3.2 Controlling via command

The following list shows examples of commands from the RapidClient.dll, in order to control the HYPER RAPID 50 laser. It is not exhaustive and just meant as a reminder of commonly used functions:

- `ConnectToServer()` establishes the connection to the power supply's PC. In case this is not successful, check the connection and its settings. Change them if necessary with `SetConnectionSettings()`.
- Send `LaserStatusGet()` in order to check the status. The status-command returns the values "INITIALIZING" and "LASER OFF".
- Subsequently send `LaserStart()` to power on the laser.
- In order to change and control the optical output-power send `MotorPositionSet()`.
- When the status changes to "LASER ON" send `ShutterStateSet(true)` in order to open the shutter. Warning: Fulfill laser safety! The laser beam needs to be directed (beam dump for testing purposes). Use: `ShutterStateSet(false)` to close the shutter.

- In order to request the IR output power use `IRPowerLevelGet()` (return value in Watt). The usage of this command depends on the configuration of the laser. When for example the SHG module exclusively produces green light, there is no IR output power therefore sending this command would reference 0.
- The following commands are more time-intense (compared to other commands): `ShutterStateSet()`, `MotorPositionSet()`, `MotorPosition1Set()` and `WavelengthSet()`. In order to wait until the requested action is completed, loop `RequestComplete()` after the corresponding command. It populates the reference with "false" while the corresponding command is in progress, with "true" otherwise. Alternatively query the appropriate command with "Get" instead of "Set".
- The life-time of each Absorber-Spot is limited and should be tracked by the command `GetAbsorberSpotLifetimeStatus()`, refer to section "Software maintenance" on page 95.
- The function ***Modulo Divider*** is described in section "Process Shutter Control" on page 66 and can be used via `PSModuloDividerSet()`.
- Send the command `LaserStop()` in order to turn off the laser.
- After the state changes to "LASER OFF" use `DisconnectFromServer()` to disconnect the link between the power supply's PC and the external PC.
- At the end of use send `PCShutDown(void)`.

These commands might be helpful to be requested on start-up (or once a day, etc.):

```
ServiceInfoGet()
StatusReportGet()
GetAbsorberSpotLifetimeStatus()
```

For periodical information retrieval like for example `StatusGet()` or `ErrorGet()` a repeating loop is recommended.

Further routine requests are recommended:

```
GetSeederPerformanceStatus()
Seeder/Amplifier/IR...PowerGet()
DiodesStatusGet()
```

NOTICE!
For further explanations and commands refer to the description "RAPID DLL Specification", located on the Documentation-CD.

10.4 Principal signal configurations

In this chapter a few examples of principal ways to control the laser system are described schematically.

10.4.1 Gate signal controls laser pulses

The conventional way of external controlling can be reached by applying the Gate signal to the ***GATE***-input (located at the rear side of the laser head). In the Rapid software choose the requested repetition rate and the function ***Internal***. When the Gate signal is set to TTL high (+5V), the laser will emit with the user defined pulse repetition rate. Due to response times the pulse output is shifted for one pulse.

In order to prohibit the laser emission, close the Gate (signal = 0V). But also in this situation a small amount of residual radiation is possible. **This function is not allowed to be used as a safety device.** Alternatively the laser can be triggered externally (software function ***External***) by connecting the trigger signal (range 400 kHz to 1 MHz) to the BNC plug located on the laser head (rear side).

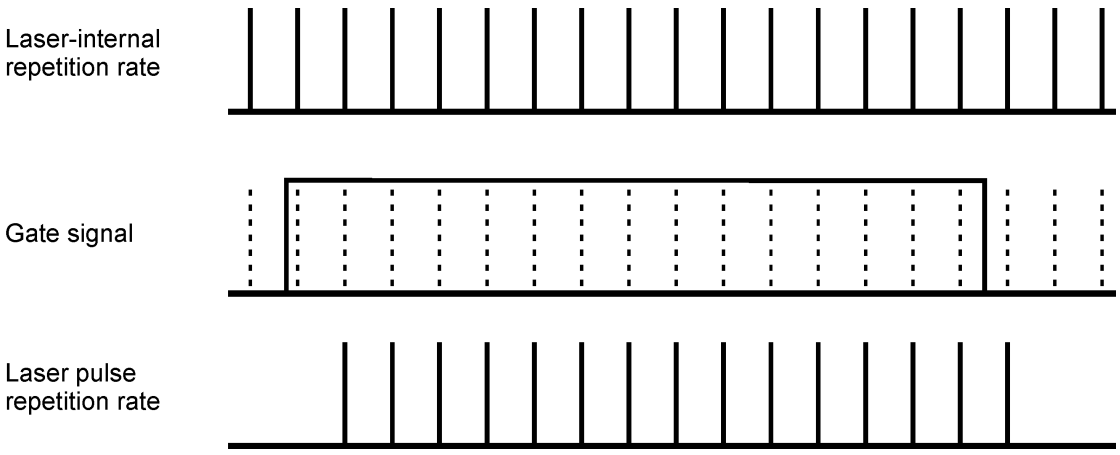


Figure 33: Laser emits as long as Gate signal is high, rep.-rate defined in the software

10.4.2 Burst-mode

The burst-mode defines an adjustable number of laser pulses with a time distance of 20 ns. Up to 10 pulses are selectable in the software. These settings offer the emission of very fast pulse sequences (50 MHz) with a user defined repetition rate. The burst-mode is described in section "Pulse picking" on page 39. Various experiences have shown that the amount of ablation for certain materials and applications can be significantly increased as well as optimizing surface structures (e.g. reduction of roughness) by using this function.

10.4.3 Emission of single pulses

In order to emit single laser pulses the following procedure can be applied: Select the requested repetition rate in the Rapid software (***Trigger mode Internal***). Apply a gate signal at the requested repetition rate to the Gate Input (located on the laser head, rear side). The signal width has to be 0.1–0.5 µs. The system saves the signal (gate high event) and emits the next available laser pulse. Due to the signal processing time there is a delay of 1 period (out of the internal pulse repetition rate).

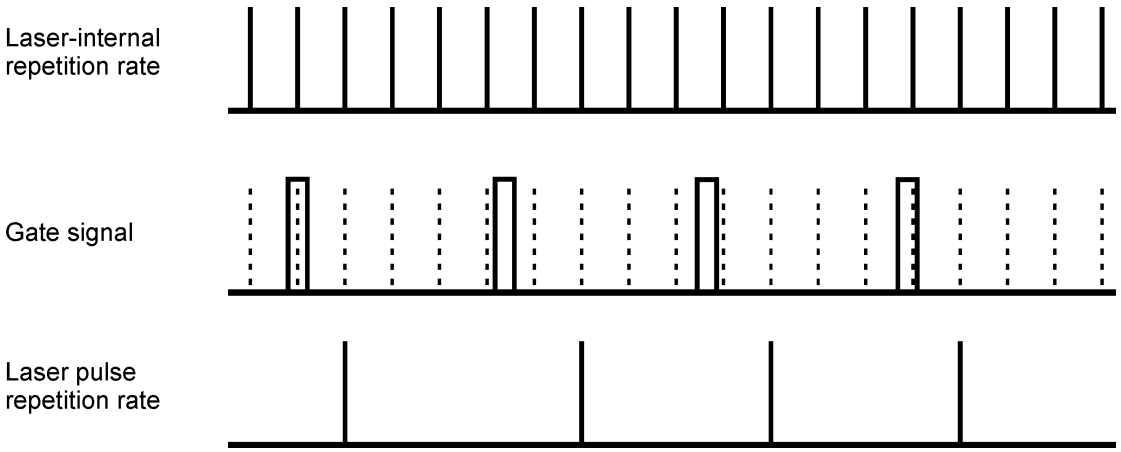


Figure 34: Gate signal is being stored until the next laser pulse

Refer to the following procedure if the gate-signal and optical output is required to be synchronized.

10.4.4 Emission of single pulses synchronized

In order to synchronize gate, trigger and optical output the following procedure should be used: Select the function in the Rapid software (***Trigger mode External***). Apply a trigger signal with the requested pulse-repetition rate to the power supply (rear side). Apply the gate signal (application TTL-signal) to the Gate Input (located on the laser head, rear side). The signal width has to be 0.1–0.5 µs. Both external signals have to be synchronized to each other in order to select the requested pulses. One possible method is to use a function generator (or the corresponding feature of a scanner or translation stage) to phase-match and adjust both signals to each other. The Gate-signal should be applied approx. 300–400 ns before the Trigger-signal. This way an uncontrolled mismatch between signal and optical output can be prevented.

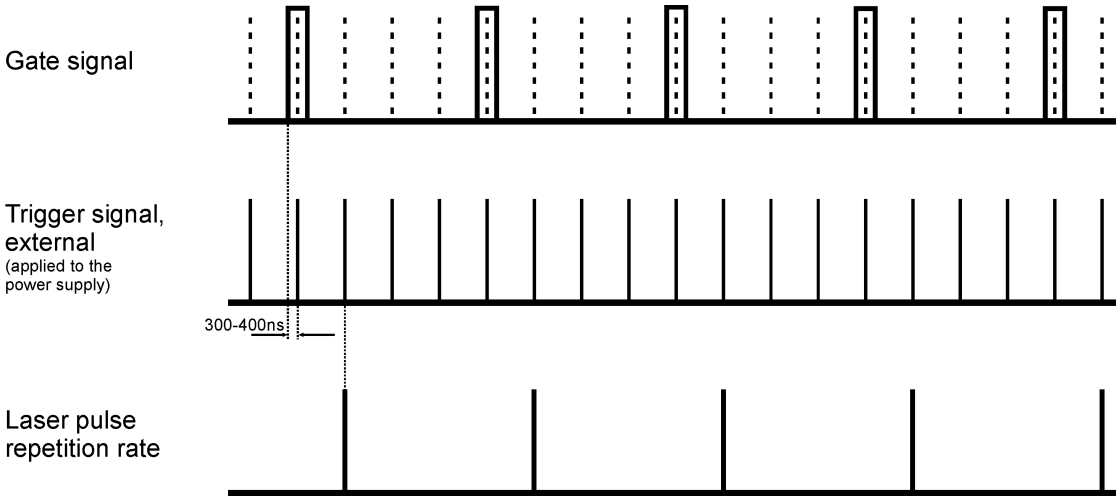


Figure 35: Gate signal is synchronized to the trigger signal

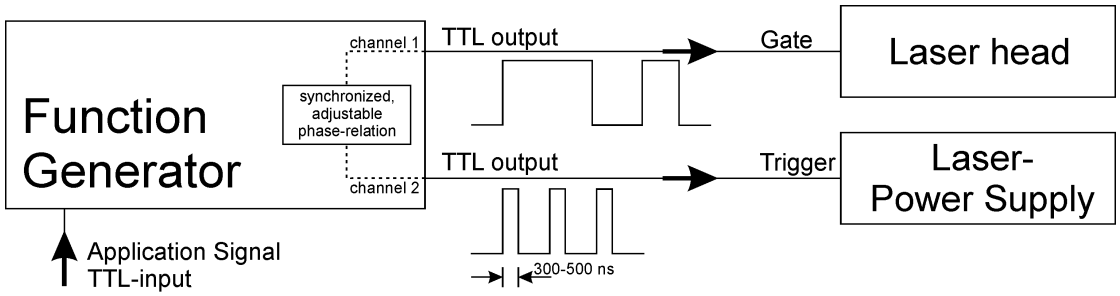


Figure 36: Function generator for synchronizing

10.4.5 Scanner - System

A common task is controlling a scan head. Generally the travel actions of a scan head have a (positive) acceleration period, a period of equal speed and a phase of deceleration (negative acceleration). The description in this section exclusively refers to the period of equal speed. The scan card needs to provide the TTL-signal, which has to be capable of excluding the acceleration phases. This way pulse energy as well as the overlap factor of adjacent pulses remain constant. The functionality of the scan card stays in responsibility of the customer.

Connect the scan-card TTL output-signal to the ***GATE***-input (located at the rear side of the laser head).

If the scan card is capable of delivering an analog output signal (0-10 V) (with a requested frequency up to 1000 kHz) in order to control the output power, this signal can be connected to the ***ANALOG***-input, located at the laser head (rear side). The relation between the voltage signal and the emission power is not linear.

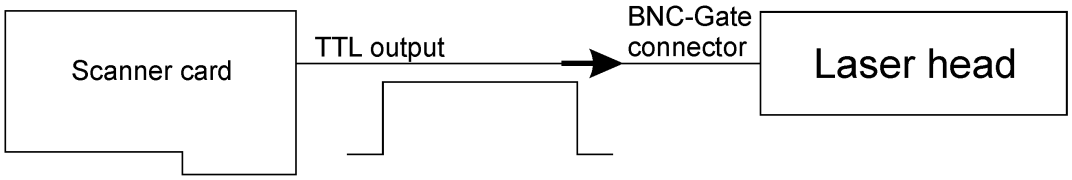


Figure 37: controlling via scanning system

NOTICE!

For further information and additional support please do not hesitate to contact us.

11 Maintenance

The HYPER RAPID 50 laser is designed for low maintenance operation. Periodical maintenance described in this chapter is necessary to be performed by the customer and be strictly followed.

Procedures, other than these described in this chapter, are exclusively subject to certified Coherent Service technicians only. In case you need any support or Service, contact your Coherent representative or refer to the first page.

11.1 Maintaining intervals

The following list displays all periodically necessary maintenance. The intervals must be observed in order to guarantee a reliable operation. Articles can be ordered by Coherent or contact your representative. For any other issue or replacement, contact Coherent Service for support.

Maintenance	Task	Interval	Order-number
Chiller cooling liquid (5 liter) CKL-1 + chiller filter (Termotek)	exchange	6 months *	1261280
Chiller cooling liquid (2x5 liter) (necessary for Hyper Rapid) CKL-1 + chiller filter (Termotek)	exchange	6 months *	1261281
S-Control	software cycle	3000 operating hours	—

** Interval deviates from instruction in the chiller manual*

11.2 Hardware maintenance

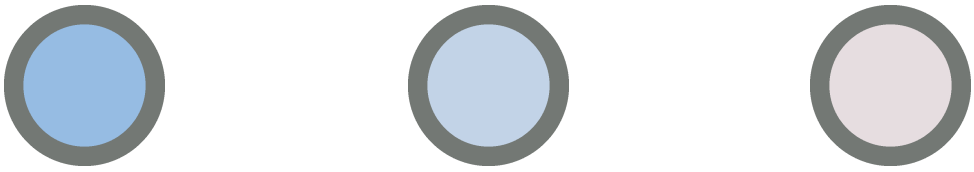
The instructions of this Operator's Manual must be strictly followed. All danger signs must be observed. Use only original parts for repair and replacement. Do not change / switch components from different OEM solid state lasers without consulting Coherent Kaiserslautern GmbH.

Service tasks and the exchange of system components is limited to Coherent-Service only.

The HYPER RAPID 50 system is a class IV/ class 4 OEM laser.

11.2.1 Exchanging desiccant cartridge

The power supply contains a desiccant cartridge, which is screwed into the rear panel. A new desiccant cartridge has a blue color. Collecting moisture results in a color change over gray-violet to light-pink. Then cartridge has to be changed.



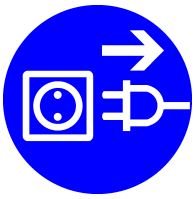
new **contains moisture** **change cartridge**

Figure 38: color index of the desiccant cartridge

Changing the desiccant cartridge is exclusively allowed by qualified Coherent Service engineers only. Make sure to provide a clean environment to avoid contamination of the power supply, e.g., dust, moisture or gases.

11.2.2 Maintaining the chiller

CAUTION!
Always wear gloves, protective goggles and protective clothing when maintaining the chiller. The coolant liquid contains corrosive components, which are not allowed to come in contact with eyes or skin. Caution with all device openings, water could splash out uncontrolled. All information located in the chiller manual have to be observed.



WARNING!
Turn off and unplug the laser system and the chiller before performing any maintenance.

Maintenance tasks for the chiller are:

- Changing the coolant: use **CKL-1** cooling liquid (included in delivery; can be ordered by Coherent). Do not use any other liquids or additives.
- Changing the filter: We recommend to change filter and coolant at the same time.

NOTICE!
After changing coolant water and filter, it is recommended to reset the software-counter, refer to section "Service menu" on page 72.

Drain coolant water from chiller

- remove hoses from the rear side of the chiller (disconnect CPC couplings)
- disconnect all electrical connections and mains cable from power
- remove the 4 screws from front side of the chiller
- drag chiller out of the rack (recommended to do this with 2 persons). Protect against drop and put the device onto an adequate platform (in order to reach the drain screw)
- position container (approx. 5 liters or 1.3 US gallons) under the drain outlet. The drain screw is located on the bottom of the chiller on the right front end (seen from the front)
- open drain screw with a metric 17 mm fork spanner and let the coolant flow into the container
- open tank inlet (chiller front side)
- make sure that chiller is turned off. Open the red "Pump bleeding" pin (black ring needs to be pushed at the same time)
- let the water drain into the container
- insert and push the red "Pump bleeding" pin back into the opening.
- attach short hoses (water change kit, included in delivery) with CPC couplings into the connectors located on the chiller's rear side
- use clean compressed air (with low pressure of max. 0.4 bar) to blow out remaining water. Never use more pressure to prevent damaging of internal devices. Observe the water flow direction! Keep away from device openings!
- close drain screw (hand tight + 1/8 turn; sealing shall tighten not crush)
- close tank inlet (chiller front side)
- remove water change kit from the couplings located on the chiller's rear side.

Drain coolant water from laser head & power supply

- connect water change kit (use corresponding CPC couplings) to the (free end of the) laser head hoses. For this purpose different CPC couplings are included in delivery. Let the coolant drain into the container.
- use clean compressed air (with low pressure of max. 0.4 bar) to blow out remaining water. Never use more pressure to prevent damaging of internal devices. Observe the water flow direction! Keep away from device openings!
- remove water change kit.

Filter exchange

- loosen screws on the left side panel of the chiller (seen from front) with metric Allen key 2.5, shift side panel slightly to the back and remove it from the device. Take care of the ground wire (attached in the middle).
- dismount transparent filter housing by loosening the large thread-ring. The water level inside the transparent housing must be below max. (due to the water drain). Remove the rest of the coolant and clean the housing if necessary. Take care of the O-ring sealing.
- dismount and replace filter (make sure to mount the filter straight into position).
- mount filter housing together with the o-ring back at its position and tighten the thread-ring (by hand).
- put the side panel back at its position and pull it towards front side in order to close the panel. Tighten all 4 Allen-key screws.
- reinstall chiller back into the rack and tighten front screws.
- reconnect all hoses of the chiller system. Observe the correct flow direction: chiller -> laser head -> power supply -> chiller.
- reconnect all electrical connections (mains and communication).

Refill coolant water

- In order to replace the full amount of coolant liquid, use approximately 5 liters (1.3 US gallons). Make sure to use exclusively the above mentioned cooling liquid.
- turn off the chiller
- open tank inlet (chiller front side). This is only permitted as long as the chiller is deactivated.
- fill in approx. 2–3 liters (0.5 – 0.8 US gallons) of coolant liquid until the indicated maximum level is reached.
- close tank inlet. Never turn on the chiller with open inlet (coolant could extrude).
- turn on chiller. The pump starts working and will stop with the warning/error "water level". An acoustic signal indicates this warning.
- repeat the filling procedure and confirm the message with "quit" (button ⬇ chiller front side). By pressing "Ein/On" ⬆ the pump starts working again.
- repeat this process until the noise of the pump normalizes and the water level does not change any more.
- close tank inlet
- reset the counter in the Rapid software, refer to section "Service menu" on page 72.

Advanced procedure to exchange coolant

An alternative procedure is described below. This way the chiller does not need to be disconnected and not completely taken out of the rack unit. The procedure might be favorably for a single person.

As long as the chiller remains inside the rack, screws located on the left side panel (needs to be removed in order to reach the filter) are more obstructed and might be less accessible.

- Open and remove the left side panel of rack unit
- remove the 4 screws from front side of the chiller
- extract the chiller to the front – half way. Make sure that it cannot drop out of the rack (e.g. put an adequate block under the chiller).
- position container (approx. 5 liters or 1.3 US gallons) under the drain outlet. The drain screw is located on the bottom of the chiller on the right front end (seen from the front).
- open drain screw with a metric 17 mm fork spanner and let the coolant flow into the container.
- make sure that chiller is turned off. Open the red "Pump bleeding" pin (black ring needs to be pushed at the same time).
- let the water drain into the container
- insert and push the red "Pump bleeding" pin back into the opening.
- use clean compressed air (with low pressure of max. 0.4 bar) to blow out remaining water. Never use more pressure to prevent damaging of internal devices. Observe the water flow direction! Keep away from device openings!
- exchange the filter as described in previous chapter
- refill the coolant as described in previous chapter. Close the tank inlet and the "Pump bleeding" pin before powering on the chiller.

Make sure that the chiller is turned off and disconnected from mains before opening any plugs. The pump could start automatically when it gets a certain amount of water.

11.3 Software maintenance

Each Seeder-spot position provides 3000 operating hours. 700 hours before the end of the life-cycle of the actual spot, a ***Warning*** appears at start-up of the GUI. 350 hours before the end, an ***Alarm*** appears. It is necessary to schedule a Software maintenance (as described in this chapter). At the end of this life-cycle the laser will not be able to start any more. S-Control **has to be started** in order to switch to next spot.

NOTICE!

In case the system is controlled via DLL-commands the life-time of the actual spot has to be regularly requested (refer to command `GetAbsorberSpotLifetimeStatus()` in the external document "DLL Specification" located on the Documentation–CD). This feature is not available in older software versions.

NOTICE!

The Warning or Alarm message will be displayed at the end of the life-time of the actual Seeder spot. It is also displayed in case a power drop of the Seeder is detected.

Software maintenance provides 11 cycles (12 available spots). The present cycle as well as the number of available spots are displayed in the S-Control main window, see section "Starting S-Control" on the next page. If the S-Control software detects a problem, it displays a message, see section "S-Control messages" on page 98.

When the S-Control software is started, the system cannot being used for processing.

After the S-Control software has found a new maintenance spot, the remaining spot number is decreased by 1 and the power status is updated. Close the S-Control software and restart the system in order to return to normal operation.

11.3.1 Starting S-Control

The S-Control software is pre-installed on the power supply's PC. In order to start the S-Control program, proceed the following:

- Start the laser system
- Turn off the laser diodes
  (GUI main window, press ***Stop***)
- Close the shutter. In case of an external shutter, it is required to be closed externally
- Close the GUI main window
- Stop the server application (if started)
- Double-click the icon ***S-Control*** on the integrated PC's desktop.
- Enter the password: **gogogo**

The S-Control window shows the following information:

Figure 39: S-Control main window

Spots left number of spots which are still available. After each maintenance cycle this number decreases by 1. When the number changes to 0, a Service assignment is necessary; contact Coherent Kaiserslautern GmbH.

Actual Spot actual spot number

Power internally measured seeder power

Progress bar	(blank window below Control): indicates an action when S-Control is in progress
Optimize	starts the software maintenance which tries to increase the power of the actual spot. In case this is not possible, a new spot will be located and the number of remaining spots decreases (by one)
Close	closes the S-Control program
Status	displays information concerning the S-Control program and the state of the execution, see section "S-Control messages" on the next page.

11.3.2 S-Control messages

If the S-Control software detects a problem during software maintenance, it displays a message:

Message	Description	Recommendation
Unfinished maintenance procedure detected. Do you want to continue this procedure?	Interrupted maintenance procedure?	Call Service
DLL functions not resolved. DLL is missing or wrong version.	Rapid_Server for external control is missing or wrong version	Check if the Rapid_ Server is started. Check if server and client version are equal
Allocation is missing.	Registry entry missing	Call Service
No connection to Driver established. Check serial port or connection cable.	No connection to the laser head established	Check serial port and/or connection cable
Driver error received. ID: (ErrorNumber)	Driver error.	Call Service, ErrorNumber important
Driver switched off. Before restart, switch on driver.	A hardware driver controlling the laser head is switched off	Restart S-Control
Dynamic link library is not connected. Maintenance is not possible in this state.	DLL not connected to server!	Check if Server is running, check versions
Dynamic link library is not able to close shutter. Maybe there is an external shutter control set.	Shutter could not be closed; might be controlled externally	Check shutter or close shutter externally. Restart S–Control
Dynamic link library reports an error. The laser system might be switched off.	DLL reports an error	Check if Server is running, check versions
The laser system detected a problem. Check the laser system and restart the program.	The HYPER RAPID 50 laser is off	Check connection power supply's PC and laser head. Check laser state.
There is no power reading detected.	S-Control needs a power reading to execute maintenance	Call Service
The laser system detected a problem.	System error	Restart S-Control or call Service
All available spots were used. Contact your service.	There are no more spots left over	Call Service

Message	Description	Recommendation
Low Powermove detected. Do you want to continue this procedure?	Power drop detected. Continue procedure?	Call Service
Motor A moving failed! Possible motor defect or connection problem.	First motor does not move.	Check all cable connections between power supply and laser head
Motor B moving failed! Possible motor defect or connection problem.	Second motor does not move.	Check all cable connections between power supply and laser head
One diode needs to be powered on to start maintenance.	S-Control was not able to start the laser diode	Restart S-Control or call Service
Only (X) Spot(s) left. Maintenance required.	Warning that the number of available spots gets low. Full maintenance is near	Schedule S-Control use or plan to contact Service
Not enough power available. Maybe there is a new maintenance cycle necessary.	The available power after maintenance cycle is lower than 2.5 W. Bad position or no optimization positions left	Repeat software maintenance or call Service
ERROR message during start up. Rapid system reports an error. See Rapid log for more details.	S-Control detected a problem during system start	Check system

12 Glossary

A

Absorber spot

Maintenance position of the Seeder. Each spot has a certain life-time. At the end of this life-time the next spot has to be activated (software maintenance: S-Control).

Amplifier

Device which receives some input signal and generates an output signal with higher optical power.

B

Beam pointing

Stability of the beam-spot position (centroid).

Beam splitter

Optical device that splits an incident light beam (e.g. a laser beam) into two or more beams.

BNC

Quick connector for coaxial cables (Bayonet Neill-Concelman)

Burst-mode

In burst-mode the laser emits a defined amount (1 to 10) of pulses with a temporal distance of 20 ns. The sequence is repeated with the selected pulse repetition rate.

C

Chiller

Cooling device for the laser system. There are two different chillers available: water to air chiller (WA) or water to water chiller (WW).

CPC coupling

This is a quick-lock coupling for water hose connections.

CU

Control unit; various power supplies located in the 19" rack

D

Delay generator

Device that controls the laser timing, e.g. adjusting frequencies.

DLL

Dynamic Link Library

F

FHG

Fourth Harmonic Generation. Frequency quadrupling (1/4 wavelength). 266 nm. Deep UV radiation, optional, not available for all products

Fiber

Optical fibers connect the pump diodes in the power supply with the laser head. They have to be protected against any mechanical contact.

Fiberscope

Optical inspection decvice for optical fibers.

Fit: m6

Tolerance of the registration pin in the laserhead foot. Refer to ISO 286-2 tolerances for shafts

Function generator

Refer to Pulse generator

G

Gate

TTL signal in order to switch the laser beam optically. TTL high enables the output of laser radiation, TTL low inhibits emission (residual radiation possible).

GND

Ground connection

GUI

Graphical User Interface

H

HE

high energy

HV

High Voltage

I

Interlock

Safety device for automatically switching off a laser power or interrupting a laser beam.

IR

Infrared. Electromagnetic radiation above the visible range for the human eye with a range of approx. 780nm to 1mm. Here infrared indicates a wavelength of 1064 nm.

L

Laser diode

Electrically pumped semiconductor lasers in which the gain is generated by an electrical current. The laser diodes reside in the power supply; they are guided via fiber into the laser head.

Lbs

Weight in pound, 1 pound ~ 0.454 kg

LD

Laser diode

LED

Light Emitting Diode

LSO

Laser safety officer. A company internal person has to be announced and (externally) certified.

M

M6-screw

Metric screw with an outer diameter of 6mm

Module

Term for an optional, optical component of the laser system, which is attached to the laser head front during manufacturing (if ordered). It can include a frequency conversion (SHG, THG on request) and/or a process-shutter.

Modulo

Software feature to reduce the optical output repetition rate out of the defined pulse repetition (e.g. 500 kHz Modulo 3 results in every 3rd pulse = 166.66 kHz).

O

OEM

Original Equipment Manufacturer

P

PD

Photo diode, internal optical power measurement

PM

Powermeter, external optical power measurement

Polarisation

Property of waves that describes the orientation of their oscillations. Electromagnetic waves such as light, along with other types of wave, exhibit polarisation.

PRF

Pulse repetition frequency

Process-shutter

Optical device which controls the optical pulses (switching on/off) during processing (gating). Residual radiation possible even when gate=0V.

ps

picoseconds (10e-12 seconds)

PS

power supply of the laser system (located in the control unit)

Pulse

Flashes of light generated with a laser (laser pulse) and delivered in the form of a laser beam.

Pulse generator

External device, capable of generating TTL signals with an adjustable frequency and phase. Might also be called 'function generator'. A frequency generator might not include this functionality.

Pulse group / sequence

Group with a defined amount of pulses. The time interval between two adjacent pulses is 20 ns.

Pulse picker

Internal device which controls the optical pulse repetition rate (triggering).

R

Repetition rate

Also pulse repetition frequency, defines the number of emitted pulses per second, or the reciprocal temporal pulse spacing (abbr.: rep.-rate). Unit adressed in kHz or MHz.

RS-232

Recommended Standard 232 (computer serial interface, IEEE)

S

Seed oscillator

Also seeder, laser which is used for generating seed light pulses of high repetition rate and extremely short pulse duration leading into an amplifier or another laser.

SHG

Second Harmonic Generation. Frequency doubling (half wavelength). 532 nm

Shutter

Safety device in the laser head used to interrupt the emitted light during laser operation.

Status report

Creates a report with actual information concerning the laser system. It is saved to the desktop of the system internal computer.

T

TEM00

Transverse mode, describes the quality of the beam profile. The perfect mode has a Gaussian propagation with the value 1.0.

THG

Third Harmonic Generation. Frequency tripling (1/3 wavelength). 355 nm

Trigger

TTL signal in order to define a pulse repetition rate.

TTL

Transistor Transistor Logic, digital signal with 0 or 5V

U

U

Unit, also RU (rack unit), 1.75 inches (44.45mm), height of 19-inch rack equipment

V

VAC

Voltage in alternating current

Variable attenuator

Device in the laser head that attenuates the power of the laser beam.

W

WA

Chiller type water-air: the internal cooling system is based on a chiller liquid, the external heat exchange is performed by an air-fan.

Waist location

Position of minimal beam-diameter

Waist size

Minimal diameter of the beam in mm

WW

Chiller type water-water: the internal cooling system is based on a chiller liquid, the external heat exchange is performed by a house-internal water circuit (provided by customer).

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S

T

U

V

W

HYPER RAPID 50 Operator's Manual

Part No. 1296089 Rev. AA